THE PRODUCTION ENGINEER

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

MARCH 1960

THE PRODUCTION ENGINEER

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THE JOURNAL OF
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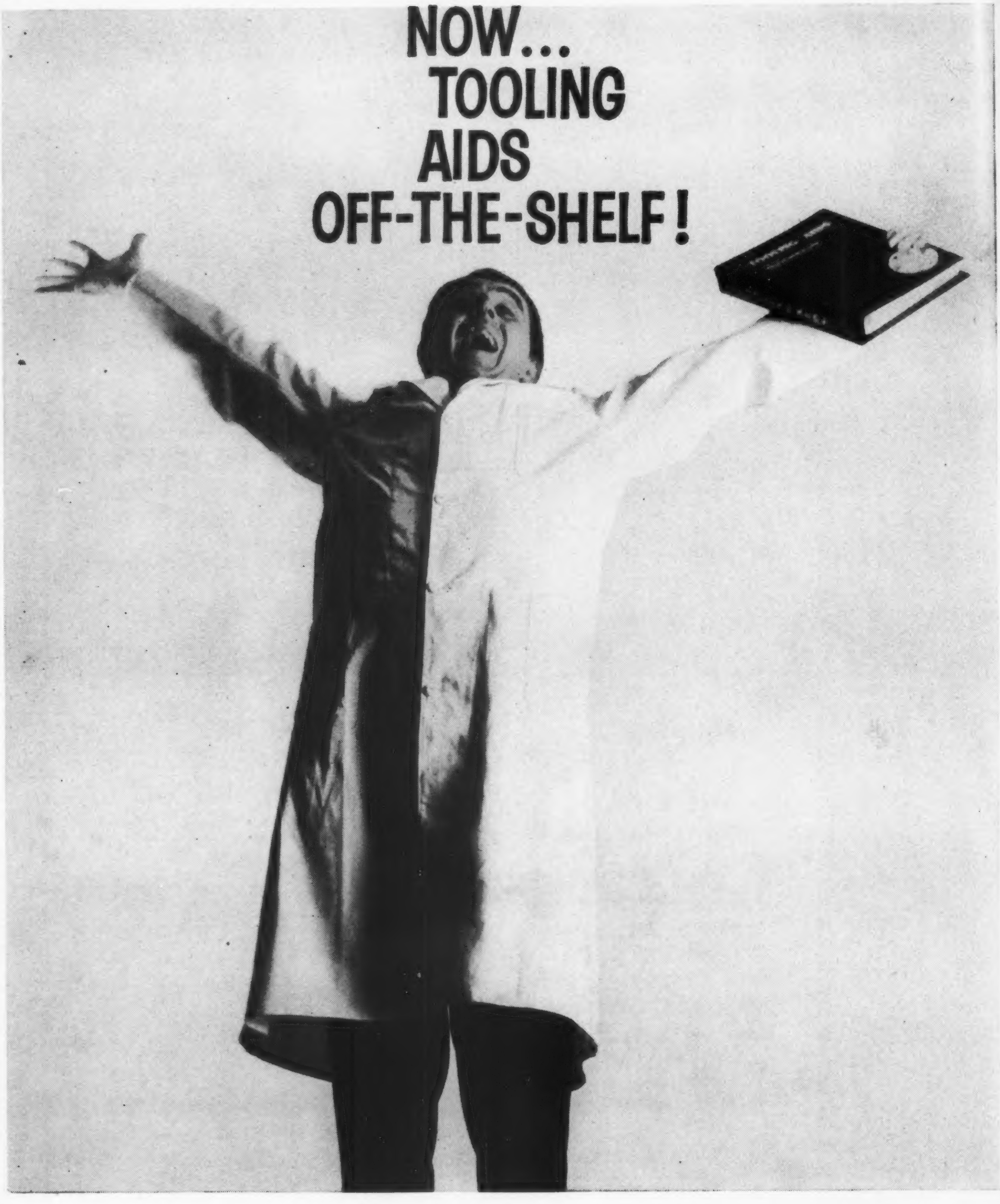
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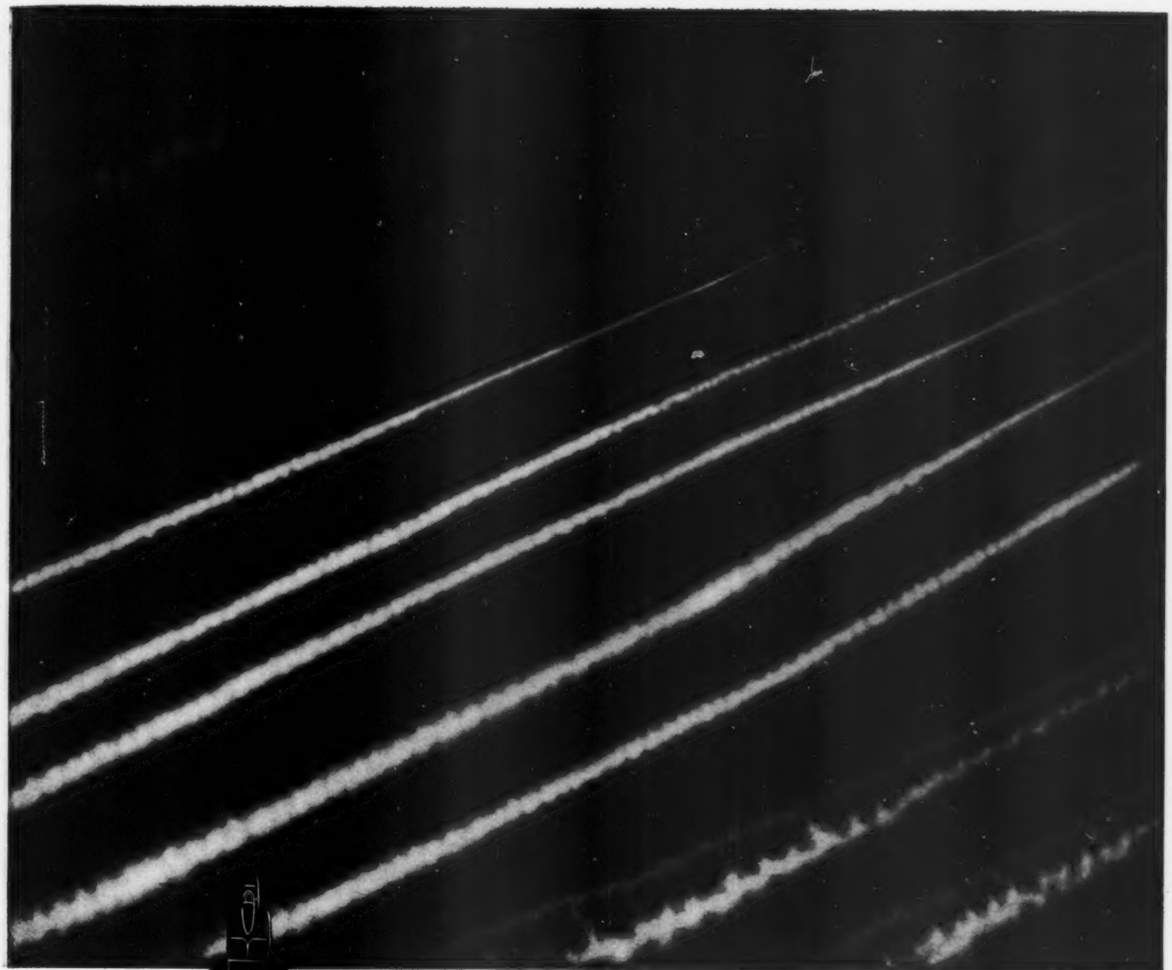

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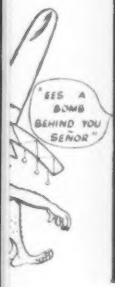

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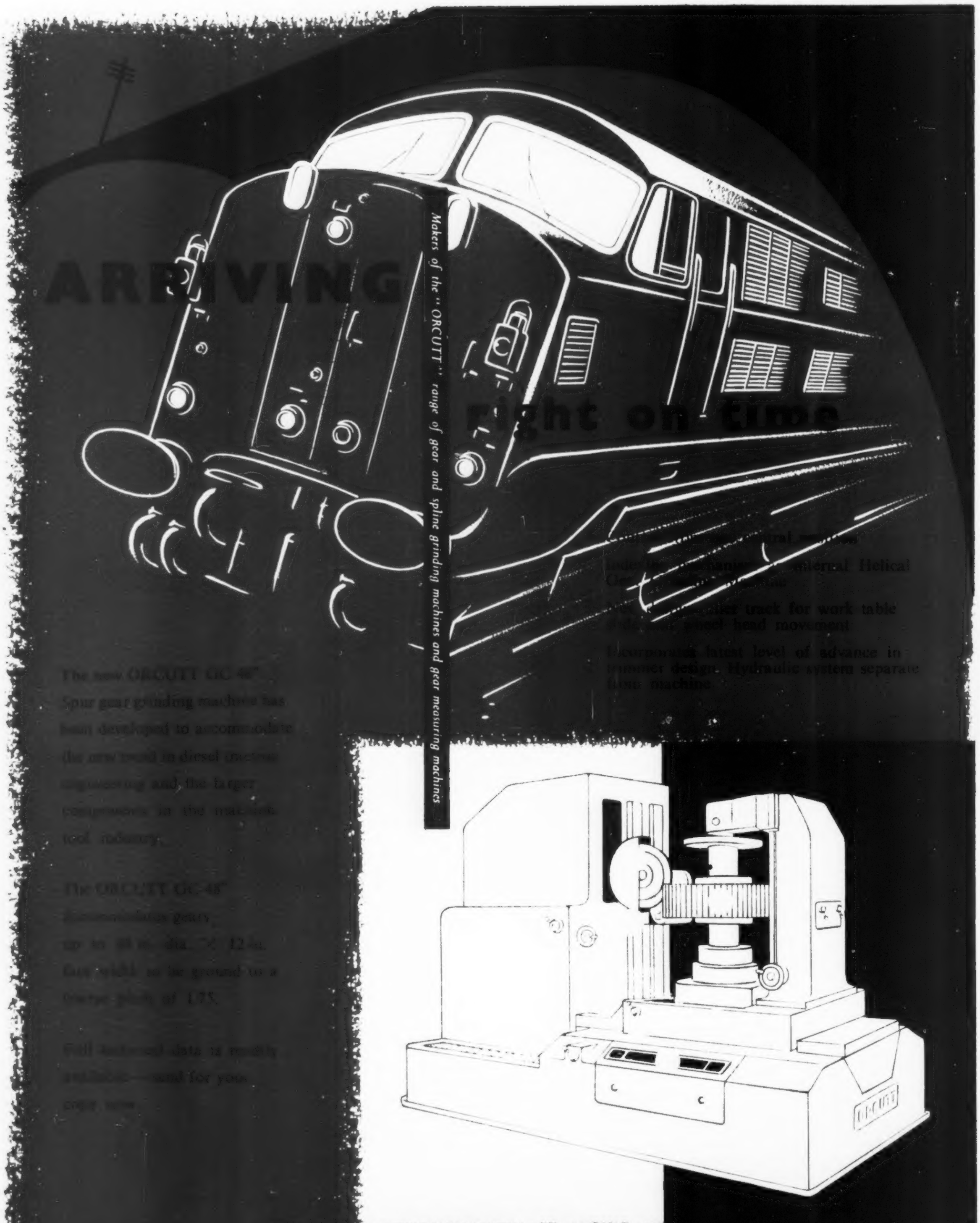
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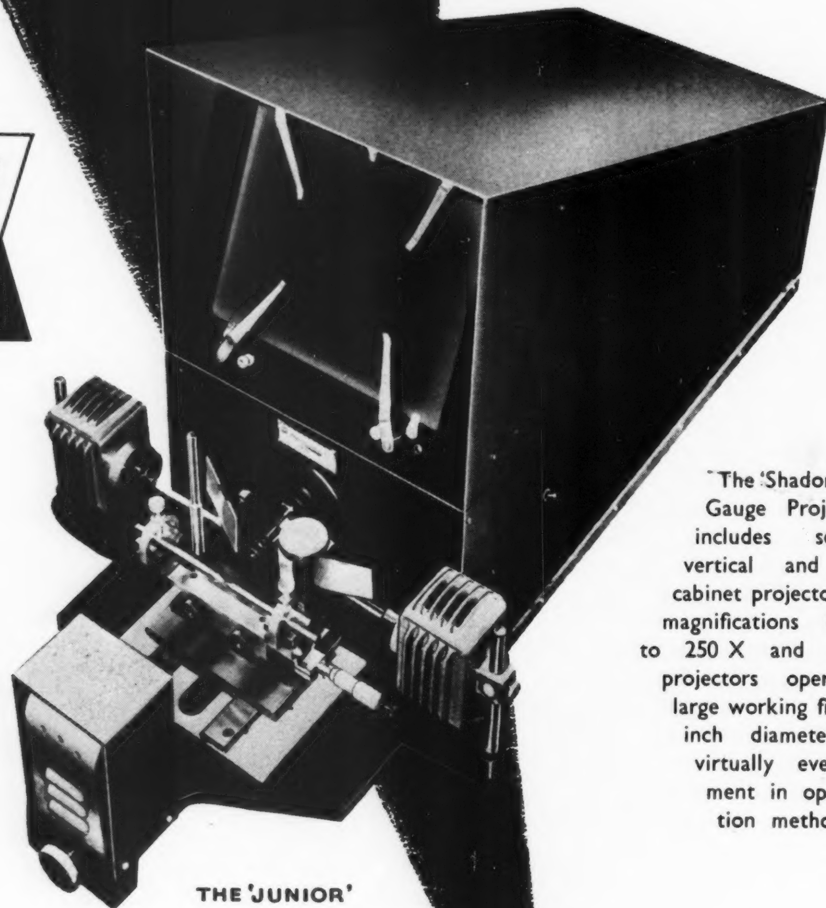

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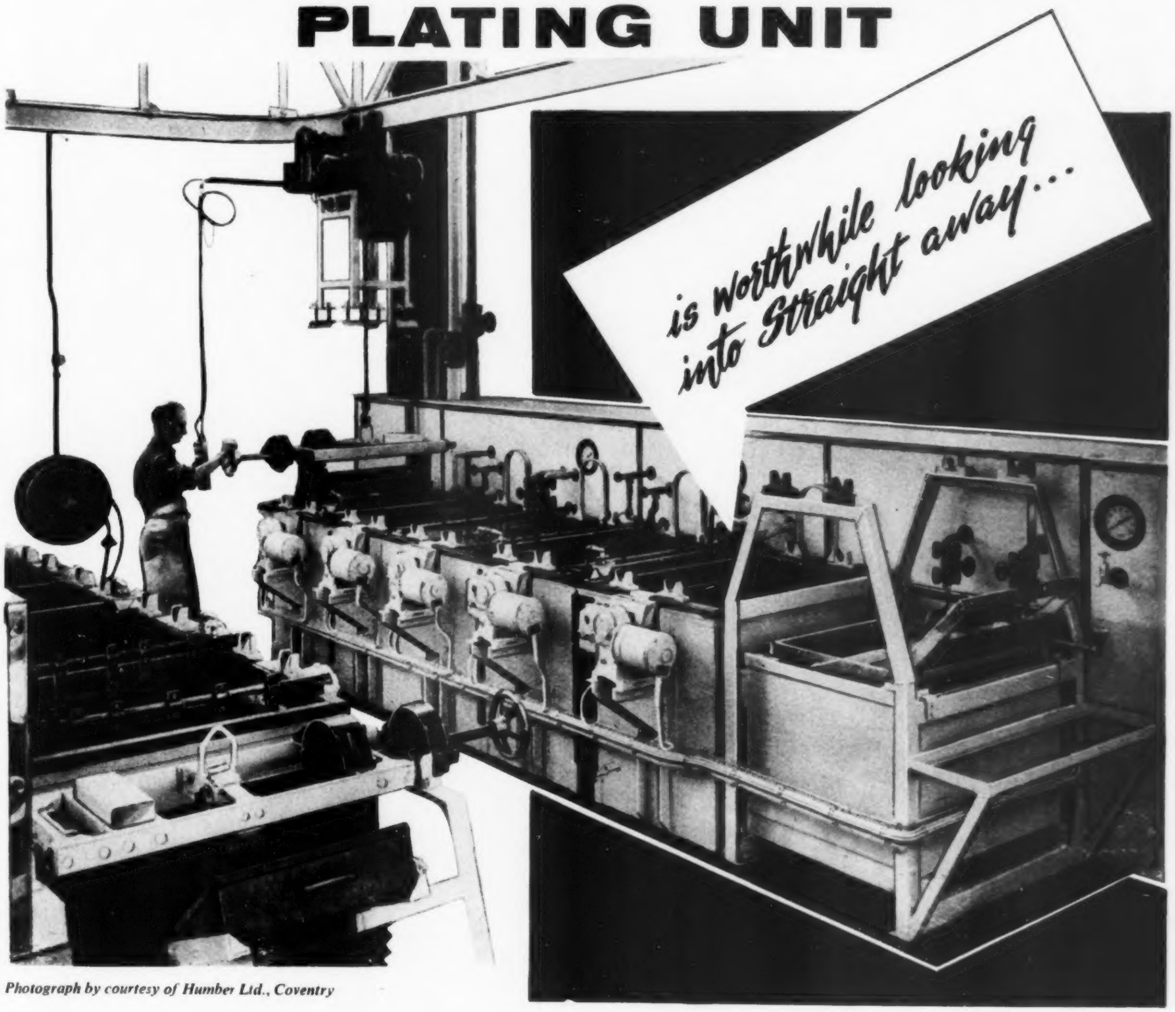

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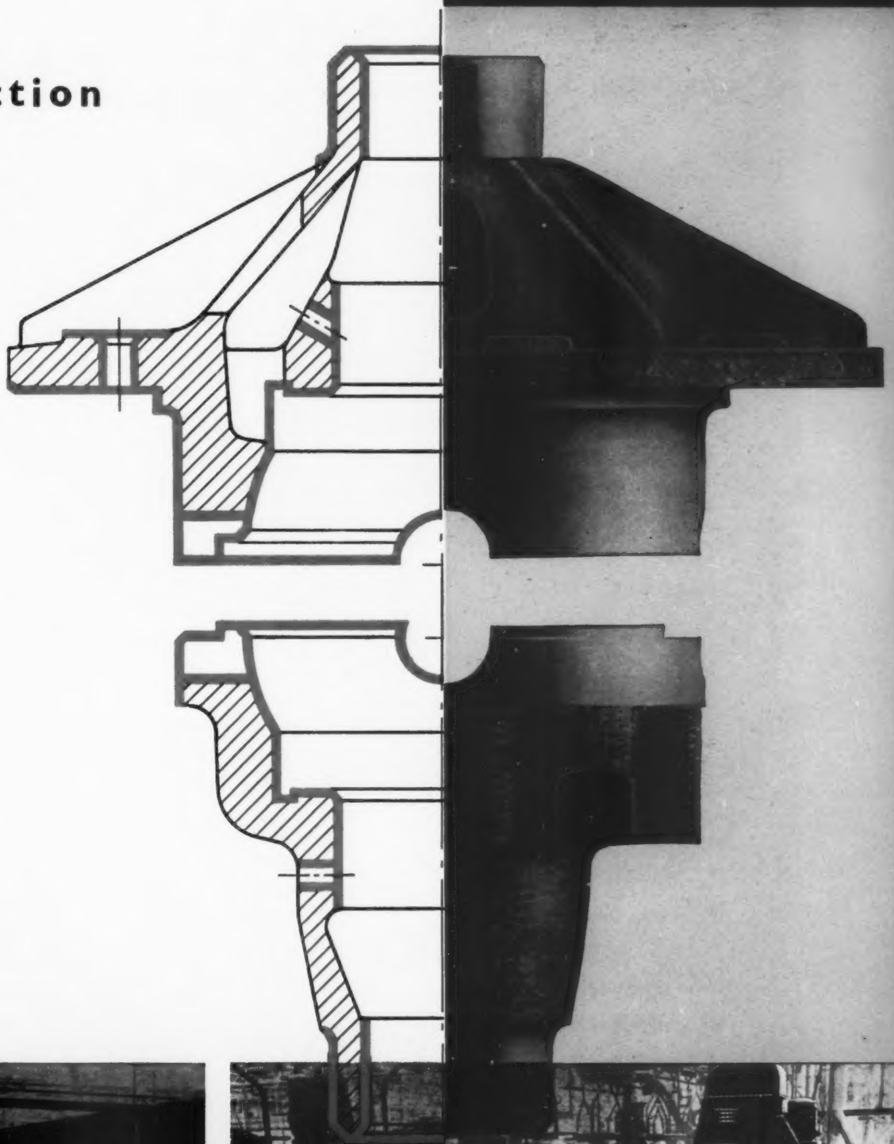

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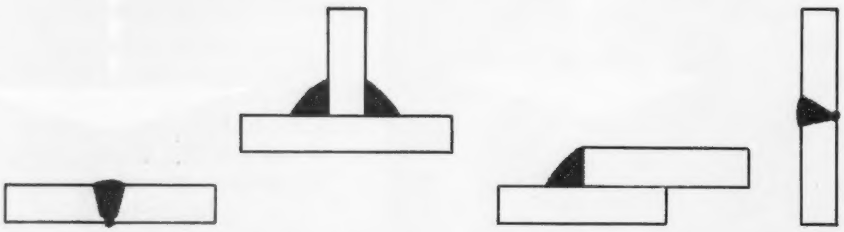

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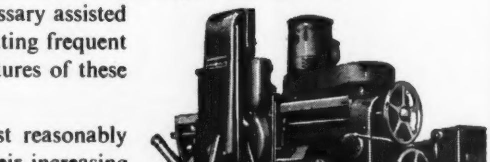

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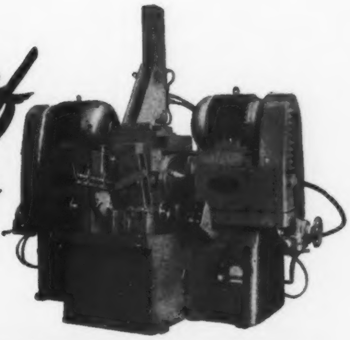

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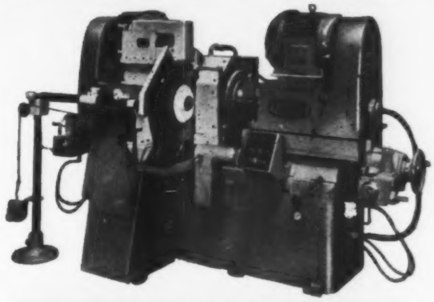

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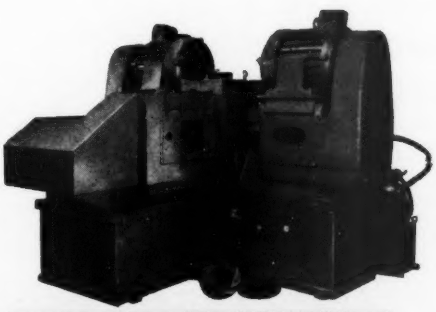

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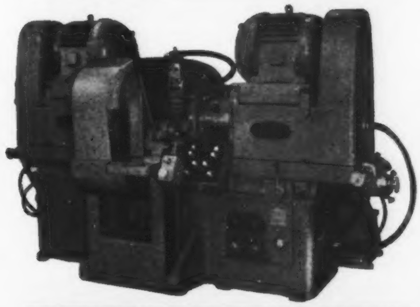

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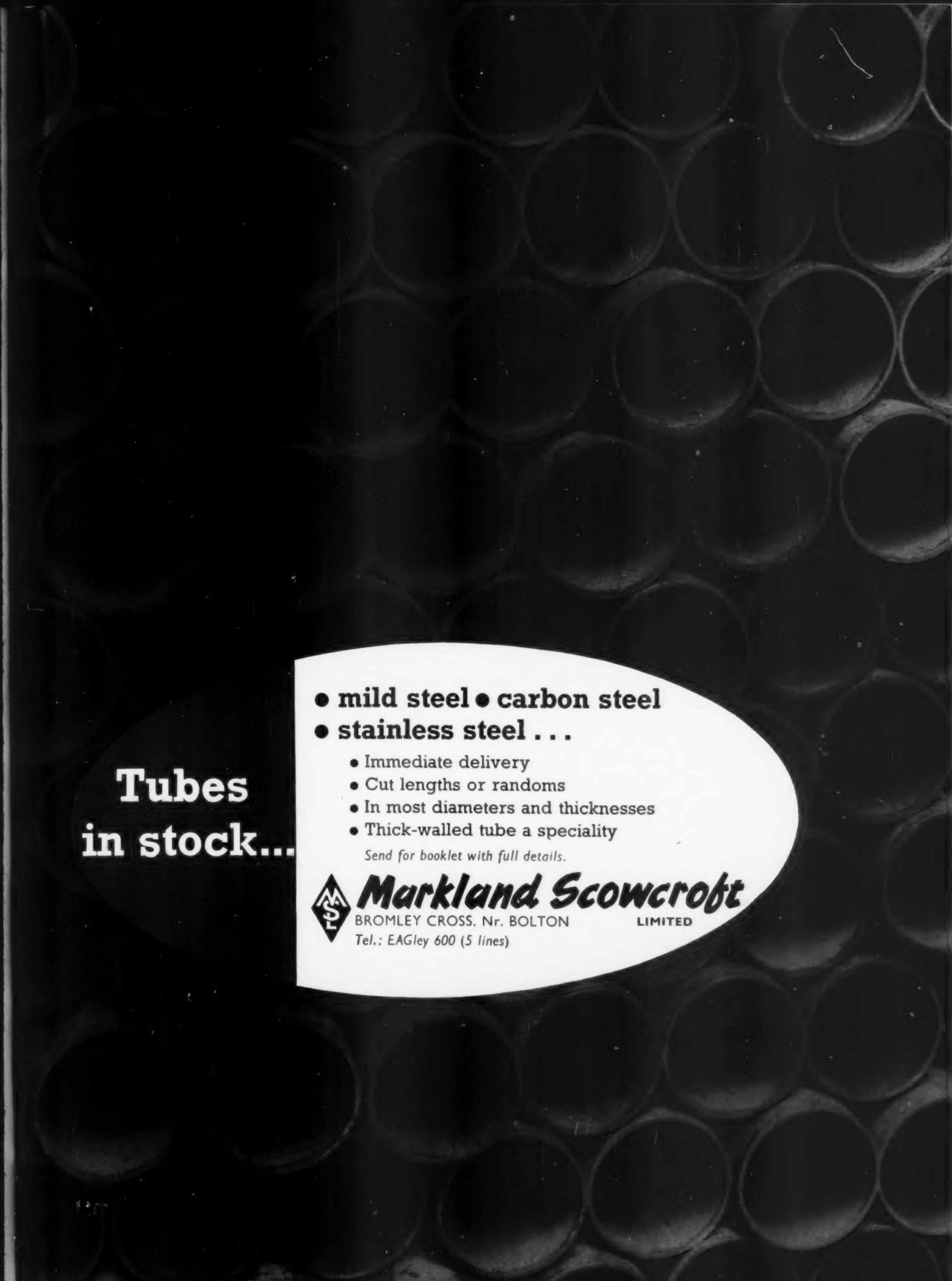
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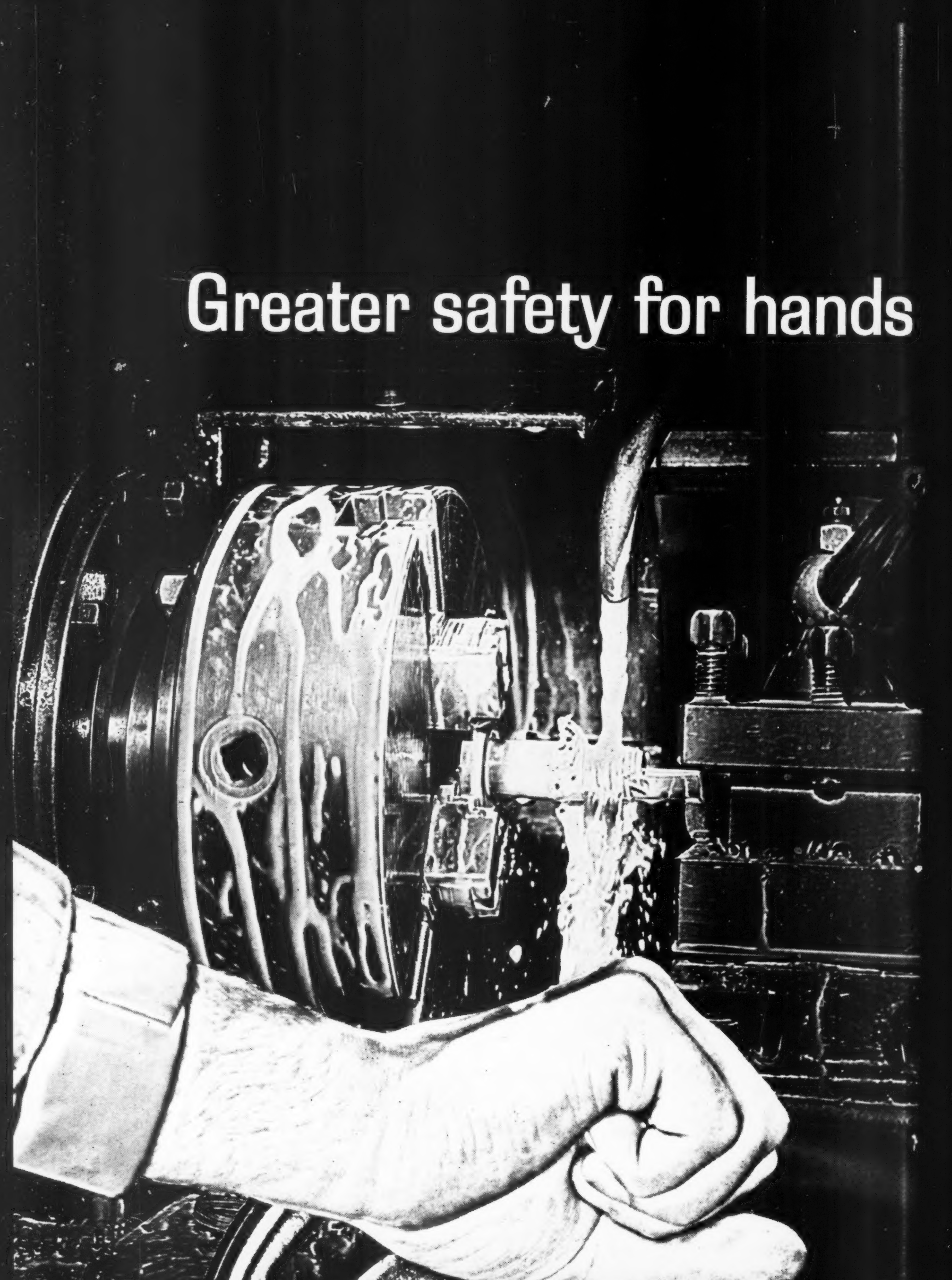
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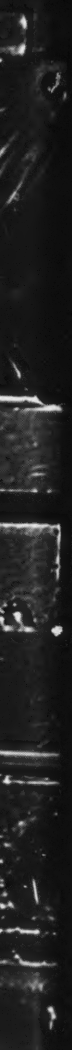

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With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

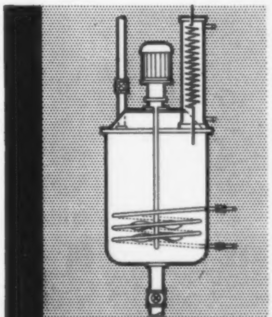
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

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The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 39 No. 3 MARCH, 1960

PRODUCTION TECHNOLOGY AT THE NORTHAMPTON COLLEGE LONDON

A report prepared for the Journal by

G. M. E. WILLIAMS, B.Sc., A.M.I.E.E.,

Head of Department of Production Technology and Control Engineering at the College

IN the December, 1959 issue of the Journal, Mr. R. C. Brewer presented "A Report on Production Engineering in British Universities" in which he remarked that he felt that the situation in the Colleges of Advanced Technology would be better dealt with separately by another author. This contribution does not describe the general picture, but it does portray the state of affairs in the Northampton College of Advanced Technology, London.

The College and Production Technology

The College is in St. John Street, Clerkenwell, between the Angel and Smithfield Market, with a nexus of the horological, instrument making, and a whole host of precision and other engineering trades around it; some still housed in buildings redolent of Charles Dickens. The foundation dates from 1891 and the main building stands on a site donated by the then Marquess of Northampton, an act commemorated by the College name. It became one of the original Advanced Colleges on 1st January, 1957 and, in addition to its strong B.Sc.(Eng.) degree stream, it now offers Diplomas in Technology in eight different subjects. Two of these, in Production Engineering and in Instrument and Control Engineering, are the special responsibility of the Department of Production Technology and Control Engineering, which was formed in July, 1958, and began functioning in the session 1958 - 59.

This Department was not founded by a purely administrative act, as it incorporated several bodies which had won their share of respect for the College in former days when it was known as the Northampton Polytechnic. These included the sub-departments of Engineering Production and Instrument Engineering and the National College of Horology and Instrument Technology which was staffed and housed by the major establishment. The former sub-department had launched in 1957 the Diploma in Technology course in Production Engineering linked with that in Mechanical Engineering, while Instrument Engineering introduced in 1958 the Instrument and Control Engineering course which, to date, is the only one in the subject approved by the National Council for Technological Awards. The National College was founded in 1945 and will cease to exist at Easter, 1960.

Delving further into the past, the Engineering Production interest has been established as an entity for some 30 years and descends from the Department of Mechanical Engineering. The Instrument Engineering connection is as lengthy, derives from the Department of Electrical Engineering and the major interest and contribution of former Heads of it, such as A. C. Jolley and C. V. Drysdale, to electrical measurements and instruments.

For many years staff of the Engineering Production wing have given regular courses in Workshop

Technology and Industrial Administration to internally registered students taking London first degrees in engineering. These courses are given in the latter two of the three years for these degrees, and the College examines the students in the subjects although the University does not. Since Northampton College today has about 400 full-time students reading for the London B.Sc.(Eng.) degree as internal students, the work merits mention in Mr. Brewer's report already cited. The College examinations, if passed, enable the students concerned to satisfy the educational requirements for the Associate Membership of the Institution of Mechanical Engineers. These courses are being continued by the Department of Production Technology and Control Engineering, and will be extended to include a short introduction for third year students to the theory of automatic control.

Until 1940 engineering production and instrument engineering were conducted within one Department. In the production field, metrology and metal cutting were of major interest and to this day these have remained important and well-equipped activities. Instrument engineering was at the time separated from engineering production, although it was mainly concerned with instrument design and manufacture and horology; the occasion was the resignation of the then Head, now Professor John Loxham of the Department of Aircraft Economics and Production at the College of Aeronautics, Cranfield.

The decision to form the new Department in 1958 thus reversed an earlier act, but meanwhile the instrument engineering side had come to serve an increasing demand for educating instrument-using engineers, as well as those who design and manufacture measuring and control apparatus. Well-equipped laboratories had been developed for these purposes and in particular some original designs of teaching apparatus have been evolved and manufactured in the departmental workshop. These manufacturing facilities have been used for the benefit of the College for many years and the new Department has been formally made responsible for this service to all Departments. A very wide variety of work is undertaken for under- and post-graduate needs, and a very high standard of design and workmanship is achieved when required.

The Diploma in Technology

A few words about the Diploma in Technology because the practice at different Colleges varies: at Northampton College, which has over one-sixth of the national total of students entered for these awards in the eight branches of technology which it offers, students are based on works for the four-year course. Each year is divided into two periods of six months, so that one is spent in College and the alternative period in works training. The works periods must total at least 24 months and the training follows schemes agreed between the employer sponsoring the student and the College. Regular visits are made to the works concerned by members of the College staff nominated as students' tutors for these and other purposes. Reports of students' progress are made by the tutors after these visits, and each student has to write a report on his training activities during each period in works. Co-operation between employers and the College has been very good and since, in the view of the College, the works period is a vital part of the education, this is most gratifying. The College is so far alone in running courses twice per session with entry in September and mid-February. Teaching staff has been nearly doubled to permit adequate rest and the maintenance of College standards of teaching. The capital resources of the College are utilised in this way for 11 months in the year, and employers are assisted by being able to arrange the interleaving of student apprentice training programmes.

Entry for all the eight Diploma in Technology courses is open to those who have passed at least five subjects for the General Certificate of Education, of which one must be English and two must be nominated subjects at Advanced Level for the course desired. Alternatively, an Ordinary National Certificate gained at the first attempt with over 60% examination marks in each subject is sufficient, with a qualification in English. All intending entrants are interviewed by the College for consideration for admission to the courses.

The first two College periods are usually to provide a general technical base in mathematics and science with comparatively little specialisation in the first year. Specialisation in the chosen course increases as the years pass — all students carrying out an item of individual work in the fourth year to test application of the knowledge gained — so that each student receives increasing proportions of tuition from the Department responsible for his course as he approaches his final examinations and last works period.

The Department of Production Technology and Control Engineering provides courses in Workshop Technology and Industrial Administration for all eight Diploma in Technology courses in the College, including that in Applied Mathematics. It also undertakes a two-year course in Principles of Instrumentation for the course in Industrial Chemistry.

The Department of Production Technology and Control Engineering

Major developments took place in the field of technology generally in the 18 years to 1958, at a pace unprecedented at any earlier period and accelerated most by the War of 1939 - 45, and later industrial changes. Among these changes production technology came of age aided by new materials, new methods, the growth of the quantitative analytical approach to industrial problems. Measurement and automatic control technique also emerged and became a topic of discussion even among laymen, and especially about the applications suggested and practised in producing goods and services. It is in this light that the formation of this Department in Northampton College makes good sense, and whilst the title is unwieldy it does express the relation and the

intention of the Department to bring the two themes together. Furthermore, as will be apparent from some examples given below, students of the Department are inevitably demonstrating the viability of this policy.

main lines of development

Development of the Department is to proceed along lines laid down in some detail in May, 1959. The work of the Department at under- and post-graduate levels will be along three main lines, all of which are established and staffed already.

The central feature of Departmental educational policy is to inculcate in every student the habit of use of objective measurement as the starting point for any act in production technology. Whilst great progress in this matter has been made since 1939, it is still the case that many production technologists in British industry act on impulse or uncertain data. It is remarkable that even excellent University graduates in science or engineering, faced with a problem in natural science, will resort immediately to scientific method based on measurement but, confronted with an unnatural problem, where the hand and brain of man has been at work, say, in organisation of effort, their training in logic is often ignored.

It is also felt that the theory of closed loop control is of profound importance even for its own sake; examples can be found throughout nature, economics, sociology and politics where a knowledge of this theory enables a better understanding to arise, albeit qualitative rather than quantitative.

The other two main lines of work are in production organisation and production methods and processes, both based on the theory and methods of the central feature which range from the measurement of human labour by work and method study to metrology and fine measurement, and extends the theory of automatic control to non-linear cases and the design of systems. Statistical methods and the use of simulators are considered essential tools with which all students must become familiar, and the choice of a course of action is to be justified on economic grounds.

It is felt that to teach management to undergraduates is not desirable, but a subjective treatment of the senior manager's place in industry is considered necessary, and for Diploma in Technology students opportunities will arise in the later works periods to give training in junior command.

The object of the work in production organisation is to describe the physiology of industry from the technical point of view, to educate in the vitally needed features of a balanced enterprise and the analysis and preparation for action of organisational work. The Department of Mathematics has for several years developed interests in the statistical techniques of Operational Research which are of great value in this connection.

extension of methods and processes

Production methods and processes is to be extended to productive industry in general and beyond the field of metalworking production with which it is at present concerned. It is believed that order can be wrung from the enormous variety of productive industry and commerce by seeking the underlying principles and classifying by them as bases. For instance, rolling and calendering are used in producing ranges of goods as diverse as heavy steel plates and asbestos cement sheets and pipes : the technology of rolling is common, but the nuances on parameters differ widely. It is also noticeable that a new process is often described in terms of an earlier one and its terminology is carried over to the innovation, although the materials and products are different. The work in methods and processes must reflect the British industrial scene, in which nearly two-thirds of productive activity is concerned wth non-metallic materials.

The design of products for ease and economy of production is also to be introduced, but this topic is to be treated at post-graduate level first.

the most important work

The two courses for the Diploma in Technology have a student body of 70 to date, supported by over 30 employers from all over the country. They are currently the most important work of the Department. That in Production Engineering is in its third year for the first time this session and the fourth year wll be initiated in September, 1960. Entry to this course is in September or mid-February. The Instrument and Control Engineering course has been running so far once per session with entry in January, the third year also beginning this session and the fourth year in 1961. It is intended to offer entry to this course also in September and February beginning this year. This is the first step towards the ultimate aim of a single Diploma in Technology in the Department, wth two or three variants in the latter part of the four-year course either to pursue with special emphasis measurement and automatic control, or production organisation or production methods and processes. It is believed that common early years can be worked out, but that it will be 1961 - 62 before any major changes in the syllabi can be introduced. A little consideration will show that the needs of the budding instrument user or manufacturer are best met by a substantially similar course, and this has always been the practice in the Diploma of Technology in Instrument and Control Engineering.

The Department is also offering a one-year course in automatic control at post-graduate level beginning in April, 1960. Entry will be confined to graduates with at least one year in industry after graduation. There will be two terms of formal work apportioned so that they may be taken separately if desired and the third term for a piece of individual work on which a dissertation has to be written. The year will end with written and oral examinations at Easter on the formal instruction and the dissertation. Successful students at the examinations will be awarded the Diploma of the College. It is hoped that those who follow one of these courses at the same time will have satisfied part of the requirements for

membership of The College of Technologists, which is to be granted for the equivalent of three years' full-time work on a subject of industrial significance at post-graduate level.

Short series of introductory lectures in the evenings are also provided by this Department, and these are concerned with the latest developments in technique.

Research is and has been undertaken by the Department and this important side of its being is essential to a proper balance of activity.

Good use is made of the Pegasus digital electronic computer and other computing machinery in the Department of Mathematics which supports all courses with its vital subject; indeed, close collaboration exists with all departments. Among others, Liberal Studies leavens the diet and also provides expert treatment with subjects such as communications in industry, personnel and trade union topics, legal and sociological matters, and there is considerable traffic with the Departments of Mechanical Engineering, Electrical Engineering, Chemistry and Physics. A joint interest in industrial vision is being developed with the Department of Opthalmic Optics.

Production Technology an under-graduate subject

Mr. Brewer's report on the University situation dealt with this matter in more than one place. One would agree with him that it is a difficult matter to decide and this is especially so when the students under consideration are taking a University first degree and, therefore, are usually lacking in works experience. Northampton College, with hundreds of students taking London first degree internal courses in engineering alongside even greater numbers taking Diplomas in Technology, is in a particularly favourable position to make some cautious comparisons. The experience to date is that the Diploma in Technology student is more mature in his approach to College education and life than the first degree man, and of the Diploma in Technology students the entrant by the Ordinary National Certificate qualification is at advantage over the man directly from Public or Grammar School with General Certificates of Education.

Entrants to all Diploma in Technology courses are at advantage if they can have a few months in works, learning basic skills and the geography of the employee's life, before they enter College. All Ordinary National Certificate holders have had one, sometimes two or more years in works before College. Enlightened employers have given some of these entrants training in production engineering functions during the Ordinary National Certificate years and these men (and women) can already proceed to benefit from the course for the Diploma in Technology in Production Engineering from entry. The entrant from the Public or Grammar School at 18, however, needs six months to become accustomed to industrial environment and where possible a year is preferable.

The speed with which the intending young student of acceptable quality can assimilate new knowledge, mature and adapt himself to changes of environment is high, and this must be taken into consideration in determining views on the correctness of teaching production engineering in undergraduate courses. A man may be too old by his middle twenties and this may account for some of the well-known difficulties with such age-groups in post-graduate courses, particularly with mathematical work.

conclusion

Northampton College, London, has formed the Department of Production Technology and Control Engineering to bring together the work in production engineering and in instrument and control engineering.

Rome was not built in a day and the Department has much to do, rejecting the obsolete and unnecessary from syllabi, introducing essential material, building up staff and facilities and preparing for a large scale expansion of the College which will occupy the next half decade.

Students of production engineering for the Diploma in Technology have been spending their periods of works training with teams of mature engineers studying applications of digital machines to stock control problems, critically investigating special automatic plant in light engineering, struggling with machine loading in the production control office—not with authority so soon, of course, but actively taking part and pressing question after question upon those showing them the way.

Students of instrument and control engineering have been doing original studies of the costs of installation and maintenance of instrumentation in process plants, which have been used subsequently in evaluating the economics of new major plant under erection overseas; one took his turn in carrying out every operation in the flow-line assembly of an instrument and then process planned every operation to assemble a new design of 4-speed gear box.

One production engineering student wants the subject of his project in the fourth year in 1960 - 61 to be the instrumentation of a heat treatment process. Clearly the Department must succeed, because the amalgam on which it is based is in line with the latest thinking and acting in production technology.

It is further strengthened because it is an independent body, a free collaborator on an equal footing with the other Departments of the College, and so no compromises are needed to fit the work in production, instrumentation and automatic control into some structure with a major interest elsewhere. Indeed, the increasing understanding that many of the dividing lines between the traditional disciplines of mathematics, science and engineering are becoming unreal is not a cause of frustration, because the Department can take what it needs freely from each field and present it in cogent form from its own point of view.

SOME ECONOMIC ASPECTS OF NUMERICALLY CONTROLLED MACHINE TOOLS

by P. W. MILLYARD and R. C. BREWER

THE technological aspects of the numerical control of machine tools have already been discussed in considerable detail[1] and it is the object of the present Paper to consider some of the economic aspects. This is not an easy matter on which to generalise, yet evidently a systematic study of the costs by conventional machining and numerically controlled machining for each individual case is quite inadmissible as the normal method of deciding whether a particular component may be more economically produced on a numerically controlled machine tool. In both time and money, such a procedure could easily cost more than it would save.

Several basic principles of the economics of numerically controlled machine tools are self-evident in a qualitative manner; when one considers, however the comparatively high cost of control equipment, a more quantitative approach is obviously desirable. The investigation reported had as its primary object, to discover whether it was possible to evolve any desideratum by means of which a decision could be made quickly as to which was the more economical method of production, numerical control or conventional manual control. There are basically two types of control system, namely positional control and continuous contour control. In the former, the moving element has to be moved from one definite point to another, the nature of the intermediate path being quite arbitrary; in continuous contour control, however, the moving element has to follow some desired path and the system has not only to specify the required information continuously, but also has to keep a continuous check on the position of the moving element and to compare its actual position with the desired or commanded position. From an economic point of view this is quite a satisfactory method of classification since, in general, positional control and continuous contour control systems have their own problems.

The first stage in producing any component by numerically controlled machine tools is to convert the information contained on the conventional engineering drawing into a purely numerical form, usually in the form of either rectangular or polar coordinates of sufficient points to define the geometry of the component. Up to this stage the decimal system of counting will undoubtedly have been used; if it is desired that the control system itself should work with any other system of counting, (for example, binary counting) then it is customary to provide a mechanical or electronic decimal to binary converter; thus, it is not necessary for the programming staff to be familiar with systems of counting other than decimal.

For a positional control system, where working is not continuous, the medium for storing the numerical information which is to be fed to the control system,

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may be either temporary or permanent in nature, but evidently for continuous contour control systems only permanent storage media can be considered. The usual temporary storage media are decade switches and telephone dials, the operator either setting up the switches or dialling to give the required x or y co-ordinate. This has the economic advantage of speed, but the disadvantage, where more than one component has to be produced, of requiring the same work to be done every time a new component is produced. The work of converting the numerical information of the drawing onto a permanent storage medium, such as punched cards, punched tape or magnetic tape, takes a longer time, but is available for subsequent use, so that we have an initial economic balance between temporary and permanent storage media, this depending largely upon the number of components.

choice of storage medium

The question of which permanent storage medium to use could be an economic one, if it fell within the user's power to make the decision, but almost invariably it is the manufacturer of the control equipment who makes this decision, very frequently bearing in mind the particular control system which he envisages. In a few systems, however, alternative forms of permanent storage medium are available.

The next stage in producing the component is to specify the required path and this is clearly limited to continuous contour control systems. There are in general two approaches; in the first place, any attempt to produce the required contour may be rejected and the goal reduced to one of approximating to the required contour by a series of short chords or tangents passing through certain points on the curve. Such a system is usually known as the interpolation system and may be further subdivided into linear and parabolic systems depending on whether the interpolated chords are straight lines or parabolas. The second approach is to generate a curve (as distinct from a series of arcs) which can be made to approximate more and more closely to the required curve, this process of approximation being stopped when the required accuracy is achieved.

The economic interest at this juncture is in the data processing. Evidently the path to be followed by the tool may be specified by closely spaced co-ordinates throughout the length of the curve, the calculations for these co-ordinates being done mentally, with possibly the assistance of a hand calculator. This sort of approach was used almost 10 years ago by the M.I.T. Servo-Mechanisms Laboratory for programming the first numerically controlled machine tool. The calculations were of necessity very tedious and programming could take more than a week for even a comparatively simple component. The disadvantages of this are two-fold; firstly, human labour is relatively costly and in the second place the arithmetical work, although not difficult, is exceedingly tedious, since the calculations throughout are to at least five or six significant figures; thus the possibility of many errors occurring is quite high. At the other extreme, one could employ a highly specialised digital computer to perform all these calculations on the basis of the barest minimum of information supplied. The cost of such a computer is so high that this method may effect no economic improvement over the tedious manual calculation, but in general the calculations would be more reliable. With present day labour and computer costs, it seems certain that neither of these extremes is universally desirable. This leads immediately to the question of where to make the compromise between these two extremes. One system in current use in this country and the United States employs an appreciable amount of arithmetical programming, but subsequently uses what is in effect an analogue computer to perform parabolic interpolations, thus tending to the extreme which tolerates no computer costs. Three known systems tend to the other extreme and perform, with a specification of only two co-ordinates, automatic curve generation for a straight line or any of the conic sections.

This requires a special-purpose digital computer or, at least, the addition of a fast curve-generator to a general-purpose digital computer. The bulk of the systems, however, are of the interpolation type and employ some form of general-purpose computer to reduce manual calculation. For medium to coarse grade accuracy there is little to choose between the various types of digital computer, and they are all appreciably more expensive than analogue computers. As accuracy requirements are increased, however, the analogue computer feels its limitations more and more and the economic advantage passes to the digital computer. A special-purpose computer, although more costly, has the advantage of working much faster than a general-purpose computer, but on the other hand a general purpose computer may, by its nature, be used for other work within the factory. The position over digital computers, then, is roughly this :- the user of a system which requires a general-purpose computer may decide to buy a computer for machine tool purposes and increase its utilisation by performing such things as pay-roll calculations, etc., but the user of a system which requires a special-purpose digital computer is virtually compelled to buy time from a computer centre, since these computers are so fast in operation that they can certainly supply at least eight to ten machine tools each engaged on jobbing work and the figure will be much higher on batch production; so far, numerically controlled machine tools are not being bought in these quantities. The situation is obviously most critical in the case of very small batches, since it is here that the computational cost per component is high.

provision of power

The next stage technologically is the provision of some power source to move the table or other moving element, but this affects the economics only in as much as the various types of motor have differing costs.

It is one of the features of numerical control as a form of automatic control in the true sense of the word, that a constant observation is kept upon the

actual position of the moving element and this is compared continuously with the required position. This obviously calls for some position sensing device or transducer, the cost of which may vary quite considerably; in general the higher costs being associated with transducers of a higher order of accuracy. A user should, of course, ensure that he does not buy a control system in which the accuracy of the transducer is too good compared with the rest of the system. Since, in a well-designed system, the accuracy of the transducer will be commensurate with the overall accuracy of the control system, the transducer cost does not appear as one of the variables which it is important to consider in the present investigation.

The two factors which predominate in positional control systems, from the economic view point, are :-

1. The costs of programming and conveying the information to the control system, i.e., cost of setting up switches (or dialling) for temporary storage or the cost of preparing tape or cards in the case of permanent storage. The ability, in many circumstances, to make this cost appreciably less than that for jigs and fixtures is one of the most valuable features of numerical control.

2. Speed of positioning, which can obviously be considerably higher for numerical than manual control—this has the general tendency of reducing the cost per component for running the machine, but evidently there is no reduction in the actual machining time. Thus in a general way numerical control becomes less and less advantageous as the ratio (machining time/time of table movement) increases. It is precisely this consideration which led the Société Genevoise to employ a play-back system with their Hydroptic 6A jig boring machine, rather than a system of numerical control. Once again this can be seen quite easily in a qualitative fashion, but a generalised quantitative argument very soon reaches a state of complexity which is quite useless for general purposes.

In the case of continuous contour control it has been found possible to give a more general analysis[1], but many of the factors involved in this analysis are not easily settled and in critical cases this could be decisive with regard to the utility of the method as a criterion for the use of numerical control.

economic forecasts

As stated previously, the most straightforward method of making a decision is to carry out a full case study of both conventional and numerically controlled methods, but this is obviously expensive in both time and money especially as the component becomes more complex. It is one of the principal objects of the Paper to discuss the possibility of finding reliable short cuts to this lengthy procedure.

The basis of the work carried out was a series of case studies taken in a specialised industry

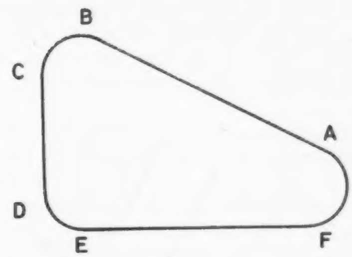

Fig. 1. Simple component to illustrate the factors affecting complexity.

engaged in research and development work. This fact brings in certain costing factors which are peculiar to this type of company and may have thrown more than the usual emphasis on frequent modification. This, however, will tend to put numerical control to an even more severe test and the basic principles, in any event, will be applicable to the much wider field of small number production in general.

Before a statistical survey can be carried out, it is necessary to establish some form of criterion which reflects the rate at which a component is produced, thus establishing an indirect knowledge of the economic factors. It may be said that the manufacturing time will be governed, in general, by the complexity of the component.

complexity factor

It would be useful at this point to enlarge a little on the subject of complexity and introduce the concept of a complexity factor. This factor must be composed of data which bear a relationship to the manufacturing time, and yet may be easily and quickly found, i.e., we seek a correlation between manufacturing time and a parameter representing complexity, whose exact nature is, as yet, unknown.

Numerous functions were considered and discarded, due to the fact that they did not satisfy both of the conditions stated above, i.e., correlation and ease of determination.

The units contributing to the length of the manufacturing time were carefully analysed[2] and the following points were selected for inclusion in the concept of complexity factor:

1. the number of decelerations (since accelerations and decelerations occur in pairs, it is unnecessary to list both);
2. the total number of curves;
3. the number of straight lines parallel to an axis;
4. the total number of other curves for which the computer has sub-routines. This will include straight lines which are not parallel to an axis and any curves which can be programmed by the final point and some parameter defining the curve, e.g., the centre in the case of a circular arc.

It is possible that when considering the number of curves, the length of these curves should also be

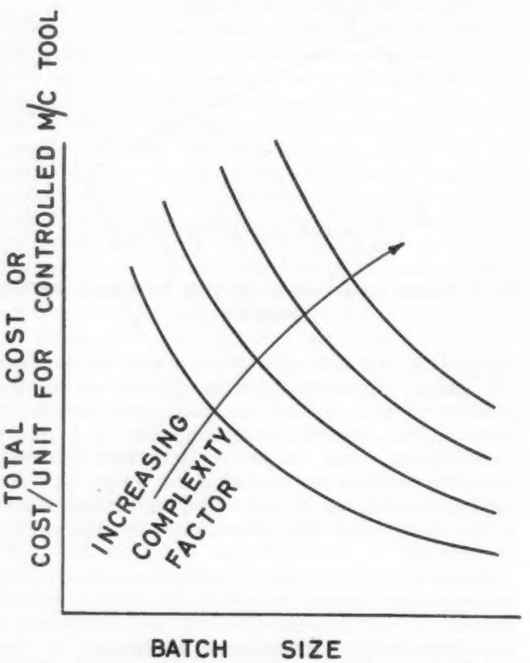

Fig. 2. Anticipated variation of total cost (or cost/unit) with batch size for various complexity factors.

taken into account. Fig. 1 illustrates a case where there are three decelerations, a total of six curves, of which two are straight lines parallel to axes, the third is a straight line not parallel to an axis and the remaining three are radial arcs.

Having established a basis for the complexity factor which looked promising, a statistical survey was made of the data collected from the case studies. At this stage, it was considered that " the volume of material removed per unit time " was not only difficult to obtain in complex cases but was also not entirely satisfactory. This can be seen easily by considering two contrasting cases, say, a component requiring the top face to be slab-milled and a cam with a rather complex track. The volume of metal removed could be the same and yet the cost contrast between conventional and numerical control would be quite different for the two components. For this reason, the concept was discarded in favour of an analysis of the manufacturing times and costs of each method.

It would be of value to discuss briefly some of the ideas that were investigated even though the results gave a negative conclusion, because at this stage in the study of economics of numerical control it is useful to know which lines of approach have given negative conclusions.

It was hoped that some relationship could be found when considering the data of both types of control as one set of figures. This was impracticable, as the correlation coefficient of the graph was calculated and found to be of the order of 0.19, thus indicating that little or no relationship existed between the manufacturing time and costs of the two production methods.

Accordingly the data were split into that pertaining to continuous control and that pertaining to positional control. Correlation coefficients were again calculated, but they were still found to be low. The figures obtained were of the order 0.14 for positional control and 0.35 for continuous control. This is in agreement with the earlier remarks that it is more difficult to generalise in the case of positional control.

The first concept of this investigation was to attempt to produce some form of graph by plotting total costs or costs per piece, against batch size for various complexity factors (see Fig. 2). It was hoped then that some method of superimposing a further series of curves representing the manufacturing costs of standard machine tools could be found. From this, a break-even point could be found indicating a minimum economical batch size for the profitable use of controlled machine tools. No satisfactory graph of this nature was produced, but a simpler form of diagram was constructed. This took the form of plotting (Es–Ep) against B × R where :

Es = Cost per unit, using standard machine tools.
Ep = Cost per unit, using numerically controlled machine tools.
B = Batch size.
R = Complexity factor.

The nature of the resultant graph is shewn in Fig. 3 and, as expected, it is evident that the data do not define a single curve relating (Es–Ep) to (B × R) but a band of finite width. Had a single curve been obtained then, for any given complexity factor and

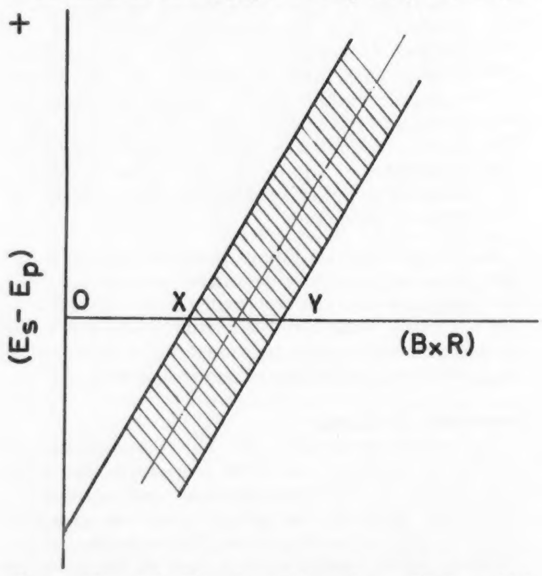

Fig. 3. The chain line shews the unique criterion which divides the regions of economic and uneconomic use of numerical control. Due to lack of 100% correlation, this line degenerates into the shaded zone of uncertainty.

batch size, the graph would shew, unequivocally, whether Es–Ep was positive or negative. The effect of the band-width is to throw in a third possibility, viz., uncertainty. Referring to Fig. 3, if $(B \times R) < OX$, the numerically controlled machine is definitely uneconomic whilst if $(B \times R) > OY$, numerical control is definitely economic.

In the range $OX < (B \times R) < OY$ the decision is uncertain.

Although this idea seemed very promising, the results of the investigation when plotted, yielded a very wide band for both positional and continuous contour control. Any attempt to reduce the width of this band would naturally reduce the confidence level considerably. Furthermore, too many of the components gave a $(B \times R)$ value which fell in the uncertainty range. Since the object was to reduce considerably the need for case study, this approach also had to be abandoned.

At this stage, when the known facts were considered, namely the poor correlation coefficient and the recurrent negative conclusions, it became apparent that no strong relationship existed on the bases considered so far, i.e., there was no one parameter which was a unique complexity factor. The next step was to investigate the data and make a comparison between the manufacturing costs and times of each method, to try to establish a rule which could be applied with some reasonable expectation of accuracy. In this a limited amount of success was encountered.

The data supporting the use of controlled machine tools was segregated from that which opposed their use, and factors which contributed to the complexity factor were listed in each case. A simple statistical analysis was then carried out, to attempt to establish a series of common factors, thus forming a simple rule.

Attempts were made to establish this rule for continuous and positional control, but again the data gathered on positional control proved to be unfruitful.

The analysis for continuous contour control gave rise to the following rules:-

Let D = Number of decelerations
R = Total number of curves
S = Number of straight lines parallel to an axis.
S_n = Number of other curves which may be programmed by specifying one point and a parameter defining the curve.

It was found that a numerically controlled machine tool can be used with an economic advantage, provided that either of the following two rules is satisfied, *viz*:

(a) When the following conditions are simultaneously fulfilled:-
(i) $D > 25$
(i) $S \leqq S_n$

(b) When the following condition is fulfilled:-
(ii) $S > 50$

The data obtained from these case studies confirms these two rules and it is estimated that the monetary savings in both cases was of the order of 40% of the total cost when employing standard machine tools.

This, however, does not give a complete picture, as it cannot be assumed that any case which does not satisfy either of these two rules cannot be economically produced on a controlled machine tool. This area of indecision however can be narrowed by the practical experience of the production engineer, as some piece parts are obviously not suitable for this type of machine tool. Estimates can be made on the other cases by assessing the degree to which they fulfil either of the above rules, but the confidence of the decision must decrease. Thus the only way to ensure complete confidence is to carry out a full study in these borderline cases.

In order to give some impression of the usefulness of this approach, Appendix A gives summarised details of 36 components selected at random. Examples marked with a single dagger (†) conform to one of the rules and the detailed case study confirms that numerical control is more economic, while those marked with a double dagger (‡) conform to neither rule and are cases where conventional control is better. All these examples represent a success for the criteria. The table shews that there is no failure case which would lead to a component being erroneously machined by numerical control, but the five examples marked with an asterisk (*) do not conform to either rule and yet numerical control is more economic.

It will be noted that the concept has ignored the size of the batch. In the case studies taken it was found that the batch size was not significant when carrying out an economic analysis, i.e., if the saving on one component was negligible, a batch of 10 would not alter the overall picture to any great extent. This is not to say that the cost per component is not reduced as the number of components increases—this fact has already been demonstrated by Brewer[1]. What it means, in effect, is that the way in which the cost per component falls is the same, within the limits of the present study, for conventional and numerical control.

Recently another Company investigated about a dozen components as part of a preliminary assessment of numerically controlled milling machines. Through the kindness of this Company, the authors were able to see drawings of the components and to have broad details of what is still an incomplete investigation. From the drawings, the authors obtained the necessary information to apply the two rules discussed previously and it was gratifying to find good correlation with the Company's findings; only two failures to agree were recorded and both were cases where the authors' rules predicted that numerical control would not be economically efficient, whereas the Company's findings, rather marginally, were in the opposite sense. It is thus felt that, without altering the rules to take account of differing circumstances the

authors' suggestions, if implemented, would have led to no serious financial loss on these components.

conclusion

The Paper has outlined the general problem of the economics of numerically controlled machine tools and analytical work which has been carried out on a specific set of data. The principles discussed can only be considered as preliminary steps in a large complex concept, which is as yet in its infancy. As the majority of the data employed in this survey were gathered from a series of case studies taken at one Company, specialising in Research and Development work, the size of the statistical population must be limited to some extent. To obtain a more accurate and conclusive picture, it would be necessary to gather data from the batch production industry, as a whole, but the results reported here should indicate the definitely unprofitable approaches.

acknowledgments

The authors wish to thank the English Electric Aviation Company for permitting the practical investigation to be done at their Stevenage Works.

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CONVENTIONAL CONTROL			*NUMERICAL CONTROL*					*COMPLEXITY FACTOR*			
Setting Cost £	*Process Cost* £	*Total Cost* £	*Programming Cost* £	*Extra Planning Cost* £	*Setting Cost* £	*Process Cost* £	*Total Cost* £	*No. of Decelerations*	*Straight lines parallel to an axis*	*Straight lines not parallel to an axis*	*Total Number of Curves*
‡0.706	0.469	1.175	0.284	0.069	1.566	0.367	2.286	12	12		12
†3.775	2.292	6.067	0.375	0.350	1.108	0.379	2.212	35	19	23	44
†3.775	2.292	6.067	0.375	0.350	1.108	0.379	2.212	25	15	16	33
†3.432	12.659	16.091	4.100	0.312	1.358	1.460	7.230	161	105	21	158
†2.498	6.156	8.654	2.610	0.387	1.682	1.206	5.885	89	73	9	82
*2.550	2.000	4.550	1.250	0.107	0.620	0.229	2.206	28	26		26
*5.458	3.182	8.640	0.793	0.091	0.437	0.278	1.599	18	7	9	17
†2.662	4.591	7.253	2.533	0.262	1.688	1.704	6.187	136	120	25	163
†3.505	3.573	7.078	2.249	0.350	2.221	0.882	5.702	186	49	3	52
‡1.191	1.191	2.382	0.246	0.350	2.221	0.882	3.699	19	18		18
†1.191	0.794	1.985	30.104	0.350	1.543	0.850	32.847	610	13	1	16
†4.121	2.858	6.979	3.574	1.500	1.113	0.325	6.512	47	28	28	56
*1.014	3.477	4.491	0.776	0.534	0.625	0.895	2.830	16	26	4	30
‡4.658	0.354	5.012	6.871	1.500	1.474	0.108	9.953	39	40	2	42
‡4.292	0.329	4.621	5.125	2.250	1.474	0.075	8.924	28	28	3	31
‡1.455	2.371	3.826	0.902	0.645	1.561	0.856	3.964	19	9	2	29
†0.881	56.158	57.039	5.354	0.750	1.814	4.835	12.753	243	25	192	247
†1.612	4.033	5.645	5.133	1.500	1.463	1.612	9.708	45	57	2	59
†2.429	2.742	5.171	0.858	1.500	1.025	0.889	4.272	34	12	24	56
‡2.375	0.247	2.622	0.475	0.375	1.108	0.917	2.875	30	32	2	36
†2.346	9.383	11.729	1.800	0.200	0.336	0.264	2.600	102	104		104
‡1.032	1.662	2.694	0.479	0.456	1.665	1.031	3.631	29	34	1	36
‡1.031	1.617	2.648	0.321	0.450	1.110	1.017	2.898	22	14	3	18
†4.605	3.116	7.721	2.620	0.283	1.593	1.200	5.696	72	36		77
*1.736	1.197	2.933	0.283	0.117	1.111	0.519	2.030	17	24		25
†3.125	7.425	10.550	0.699	0.675	0.218	0.451	2.043	33	8	10	22
‡1.102	0.393	1.495	0.404	0.195	0.507	0.394	1.500	11	8	2	10
†6.375	3.375	9.750	1.375	0.500	2.596	0.994	5.465	56	35	23	58
‡0.190	0.183	0.373	0.609	0.042	0.214	0.117	0.982	10	5		5
†2.340	3.279	5.619	0.950	0.851	1.688	0.503	3.992	123	39	29	122
†2.340	8.452	10.792	1.709	0.857	1.688	0.845	5.099	218	180	43	261
†4.148	1.459	5.607	4.996	1.250	1.762	1.402	9.410	41	54		54
†5.281	3.156	8.437	1.190	0.425	0.545	0.425	2.585	25	12	18	34
†3.381	3.271	6.652	0.442	0.750	1.932	0.374	3.498	51	48		48
†8.237	9.625	17.862	1.954	0.735	1.892	1.492	6.073	42	24	26	50
*4.709	5.619	10.328	2.728	0.411	1.058	0.742	4.939	38	28		32

COPY TURNING LATHES
(Part II)

A review by I. B. KING, G.I.Mech.E., A.M.I.Prod.E.

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This Paper is divided broadly into three parts: the first describing, in general terms, the basic principles used in copy turning systems; the second dealing in more detail with machines which are in current production, particularly those designed specifically for copy turning purposes; and the third presenting practical examples of how these types of machines have been used to advantage.

Part I appeared in the January Journal. Part III will appear in the May issue.

PART I has described briefly the basic copying systems, but more sophisticated types of copying lathes are available with a wide variety of special attachments and cycles of operation which allow a greater flexibility in the use of the machine, together with an improvement in the performance, compared with the standard lathe fitted with a copying attachment.

The following items cover the main additional features.

recessing slides

For workpieces which require recesses for circlips, narrow shoulders, accurate dimensioning of shoulders, turning down rough uneven edges on forgings and castings, an auxiliary slide can be fitted to carry tools to undertake these and similar functions. Motion of the slide is normally at right angles to the axis of workpiece rotation, but some manufacturers supply attachments which can be swivelled some 30° either side of the normal, thus allowing small undercuts to be machined.

Design of the slide allows a number of tools to be used; also, on the larger machines, a number of recessing slides can be fitted.

The slides may be operated either by hand or under power. If the machine is equipped with automatic cycle control, the required slide can also be controlled within the cycle. When an automatic cycle is possible it will very often allow rapid approach of the tools, to plunge cut at a preselected feed rate, a period of tool dwell, retraction at a preselected feed and then completion of the cycle with a rapid return.

Fig. 29. Recessing slide fitted to a V.D.F. Unicop I lathe.

Fig. 30 (below left). A three-way turret tool holder, with automatic indexing, fitted to a V.D.F. Unicop IV.

Fig. 31. The indexing template holder used in conjunction with the three-way turret.

multi-tool holders

It is normal for the copying slide to be fitted with a single, single-point carbide tool. If, however, the material to be turned causes excessive tool wear it may be desirable to use separate tools for roughing and finishing. To meet this requirement multi-way tool boxes can be provided. On simple machines a four-way box type tool post may be adequate, the tools being preset before use, and indexed by hand after the appropriate cut has been taken.

For machines with automatic cycles, turret type tool holders are available which automatically index. In some cases this is in conjunction with an automatic change of template. If, however, only one template is used, parallel roughing cuts may be taken by having the copying slide fitted with stops; alternatively all tools may be under template control.

automatic cycles

The types of automatic cycles possible range from the simplest one where there is a rapid return motion of the tool after the cut has taken place, through multi-cut cycles to arrangements involving automatic loading and unloading, varying speeds and feeds, control of recessing slides, etc.

There is a variety of methods used to control the machine and these will be described in more detail in later sections.

templates

Either flat or round templates may be used and the carrier can normally accommodate both types. Particularly where multi-cut cycles are possible the holder for flat templates is capable of carrying a number; indexing of the holder may be either manual or automatic.

For setting purposes the template carrier may be moved parallel to the work and also a slight amount of lateral movement is possible to ensure that the template is parallel to the workpiece. Normally micrometer adjustment is fitted. Diametral setting is achieved by the adjustment of a slide, carrying the

tool post, set normal to the work and mounted on the copying slide.

On a few models, adjustments in diameter are by movement of the tracer head.

multi-cut cycling

Two methods are commonly used :

(a) in which there is a multi-template holder which indexes a new template into position to control each cut — indexing may be either manual or automatic;

(b) in which stops are fitted so that a number of straight passes are taken before the final cuts are made under template control. The stops may be brought into position either manually or automatically.

speeds and feeds

For maximum cutting efficiency the correct cutting speed should be maintained irrespective of workpiece diameter. On slender jobs the changes are not significant but on large diameter work such as turbine discs and where shafts have considerable changes in diameter, some method of varying the spindle speed can be achieved either in steps, or where the control can be such as to give a continuous change. With stepped control the number of changes is limited usually to two or four, but occasionally eight steps are available. Where the spindle speed is infinitely variable there is a maximum speed variation of about 1 : 8.

The advantage of the system having continuous control is that the correct cutting speed is maintained at all diameters, within the range of the machine, whereas with stepped control it is only possible to change to the nearest convenient speed within the ratios previously selected.

For stepless variation two main methods are used, the first being the control of a D.C. driving motor, and the second the use of a mechanical variable speed gear of the P.I.V. type.

Where stepped changes occur A.C. induction motors of the change pole type offer one solution, whilst for constant speed motors gears can be changed, under load, by means of electro-magnetic clutches.

Variation in feeds depends on the type of copying system concerned, and whether the longitudinal feed is controlled by the tracer or not. For machines which do not have tracer control of the feed rate,

Fig. 32. Hand-operated swivelling template holder.

the machines which have a hydraulically driven feed normally have an infinitely variable feed, whilst the mechanical drive machines are normally limited to a 2 : 1 change under load.

Where a constant cutting speed device is fitted it is possible, on some machines, to achieve a constant feed rate, i.e., a constant feed per revolution of the work and this is achieved by having a connection between the main spindle and the feed system. In

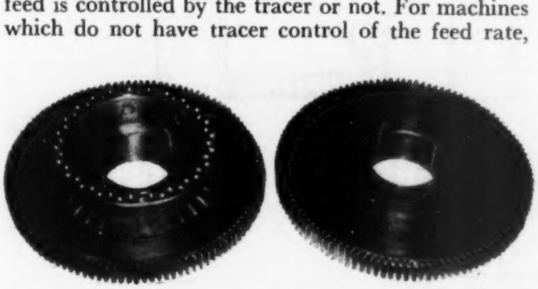
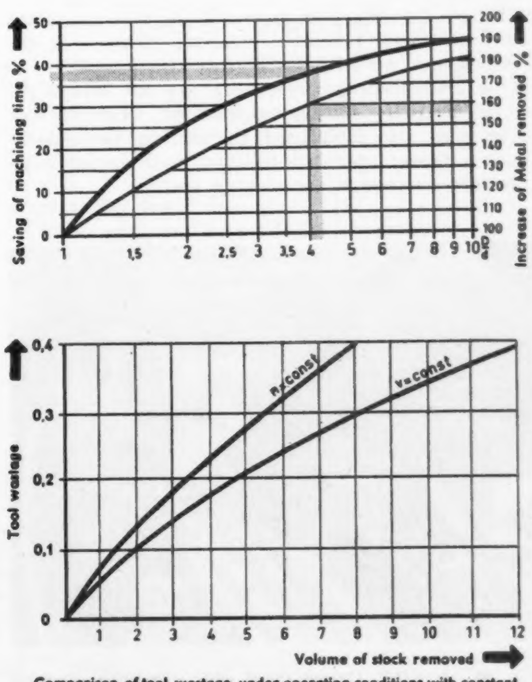


Fig. 34. Two turbine discs machined on a Monarch lathe with constant cutting speed show the uniform finish which is obtainable.



Comparison of tool wastage under operating conditions with constant spindle revs. and constant cutting speed.

Fig. 33. The results of constant cutting speed control as fitted to a Max Müller lathe.

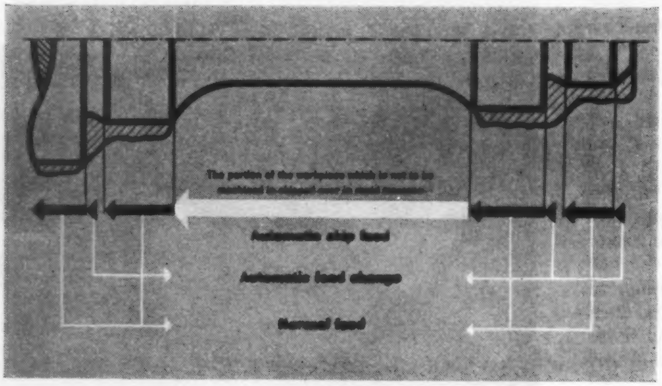


Fig. 35. Typical use of variable speed control.

addition, on some machines an additional rapid feed, known as a skip feed, is possible; this causes rapid travel over the parts of the work which do not require machining. By this means the cycle time can be reduced.

work holding

Naturally the type of work holding device will depend on the type of job and also whether loading and unloading is automatic or manual.

Chucks can be fitted with pneumatic or hydraulic clamping. Control of the clamping circuits, if not automatic, is usually through foot operated switches, so that the operator has both hands free to hold the work.

Where disc type components have to be machined on both faces, precision chucking devices of the "Ringspann" or M.S.E. "Perfect Grip" type are of value, and may save a separate set up. Where the work needs to be turned between centres, face drivers are very often used, the machine being fitted with a power operated tailstock with initial over-pressure to engage the driving teeth.

For long slender work which is required in quantity it may be possible to use a bar feed device, the bar feeding through a power operated collet. Normally the bar feed incorporates a magazine which allows considerable running times of the machine to be achieved.

Use of automatic loaders and unloaders sometimes requires that the material should be pre-machined, and also centred. The loader is magazine-fed and if more than one machine is needed to complete the workpiece, the machines can be connected by means of conveyors; the first machine unloading on to the conveyor which passes the work to the magazine of the second machine.

Where automatic unloading equipment is fitted it is often possible to incorporate into the cycle an

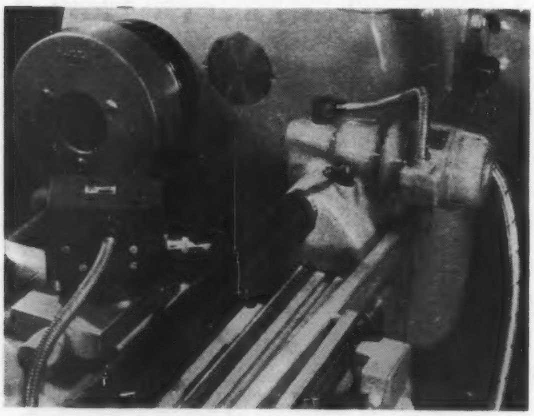


Fig. 36. A V.D.F. Unicop fitted with automatic swivelling template holder and a + G.F. + work driver for turning between centres.

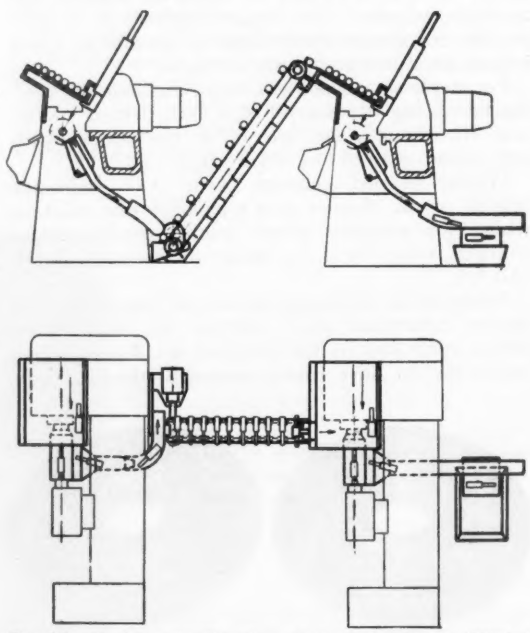


Fig. 37. A diagrammatic view of two + G.F. + KDM 7 lathes fitted with automatic loading and unloading and linked by conveyor.

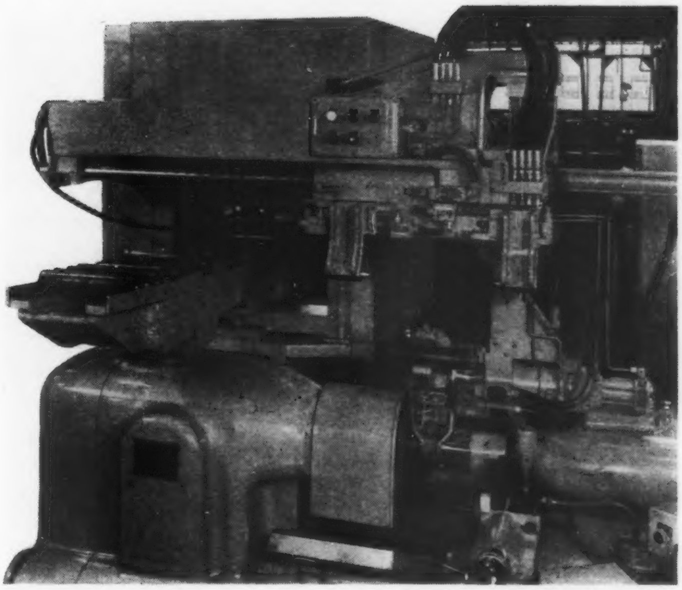


Fig. 38. A Monarch copying lathe fitted with a shuttle work handling device and magazine feed.

inspection point which measures the piece immediately after machining. If the part is outside the tolerances specified, some form of indication is possible. Alternatively predetermination of tool life can be used as a basis of acceptance, and tools changed after a number of cuts have been taken, so that the workpiece dimensions do not fall outside the tolerances set.

To facilitate using the machine the tailstock may be power-operated either electrically, pneumatically or hydraulically. As mentioned above, operation can be from a foot switch to allow the operator's hands to be free. Since the workpiece may become hot during cutting, provision is normally made to accommodate changes in length without increase in the tailstock pressure.

In the case of machines with automatic cycles, the movements of the tailstock can be incorporated.

wet turning

If necessary, wet turning equipment can be fitted to most machines as an extra. The advantages of wet turning are mainly:-

(i) on some materials there will be an increased tool life, possibility of higher cutting speeds and improved chip forming;

(ii) the workpiece can be kept cool — this is particularly valuable when close tolerances have to be held or there is a risk of distortion;

(iii) in boring operations the chips can be cleared by flooding the tool; with cast iron, coolant will prevent the formation of dust.

Coolant may either be flooded on to the work or ducted through the tool and the flow may be controlled in the machine cycle, so that coolant is pumped on to the job only whilst the machine is cutting.

duplex copying

Where opposite shoulders are normally turned in two set-ups, it is possible to use only one set-up if a duplex tool holder and two templates are used. It will be seen by reference to Fig. 39 that the first tool feeds from right to left, and is controlled by one template; whilst the second template controls movement of the second tool with the feed directed from left to right. This method may be used for internal or external copying.

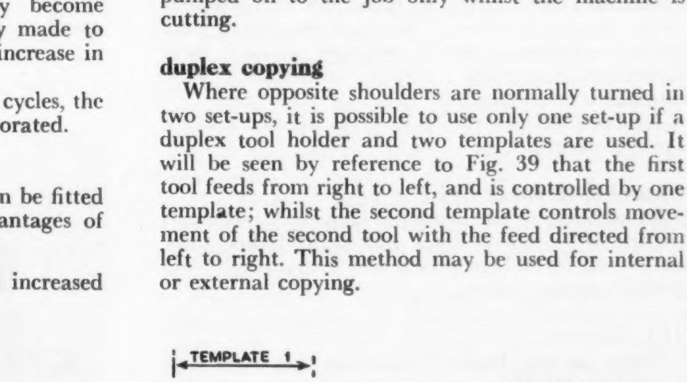


Fig. 39. Duplex copying.

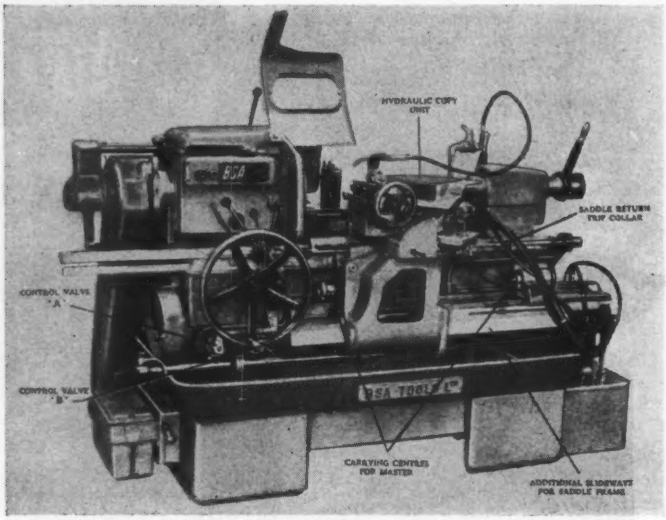


Fig. 40. B.S.A. hydraulic copying lathe.

British machines
B.S.A. Tools Ltd.

In addition to their template controlled multi-tool production lathe, this Company manufactures a hydraulic copying lathe which is based on the multi-tool lathe. The copying slide is fitted at the front of the machine, together with the master component, at 45° to the machine's centre line, whilst for recessing a cam-controlled rear slide may be fitted. A variety of spindle speeds, front and rear slide feeds, is available and can be changed by means of pick-off gears. (Fig. 40.)

It is possible after completion of the cutting operation automatically to return the copying slide to its starting position. This is an electrically controlled attachment and is arranged to have three cycles of operation — namely, automatic, semi-automatic and manual.

Air-operated chucks, collets or fixtures can be fitted if desired.

Churchill-Redman Ltd.

In addition to the hydraulic copying attachments for the 'L' range of tools and facing lathes, there are two series of high production hydraulically controlled copying lathes.

H.L. Series

There are five basic machines in this series with a capacity of 12 in. and 14 in. diameter over the copying slide admitting 20 in.-60 in. between centres.

The saddle carrying the profiling slide is hydraulically powered by a cylinder located between the bed ways, and can be varied from 0 in. - 17 in. per minute, together with rapid traverse in either direction. The hydraulically-controlled slide is set horizontally at the front of the machine and at 45° to the centre line. The template or master component is mounted at the back of the machine.

A toolslide is carried on a beam at the rear and this slide, which is hydraulically operated, has a fast approach, variable feed, a rapid return and can carry a number of tools. This slide can be swivelled for bevelled faces or undercuts. Where parallel roughing cuts are necessary, the rear toolslide can be fitted with a longitudinal feed.

Automatic multi-cut control equipment can be fitted allowing four cycles to be completed. Depth and length of cuts are controlled by means of adjustable trips fitted to an automatically indexing four-position trip bar.

Automatic spindle speed change can be provided by the fitting of a two-speed driving motor. The speed change ratio is fixed at 2 : 1 and is selected

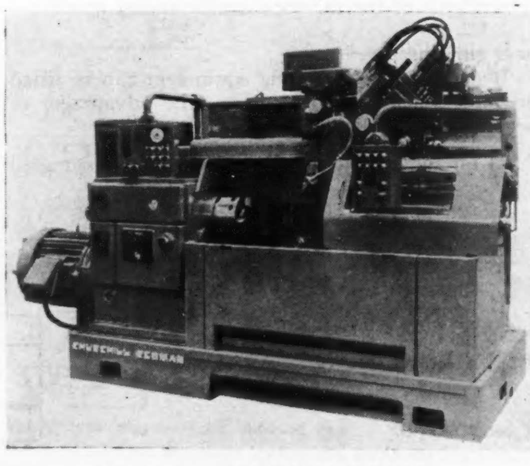


Fig. 41. Churchill-Redman Model P.5.

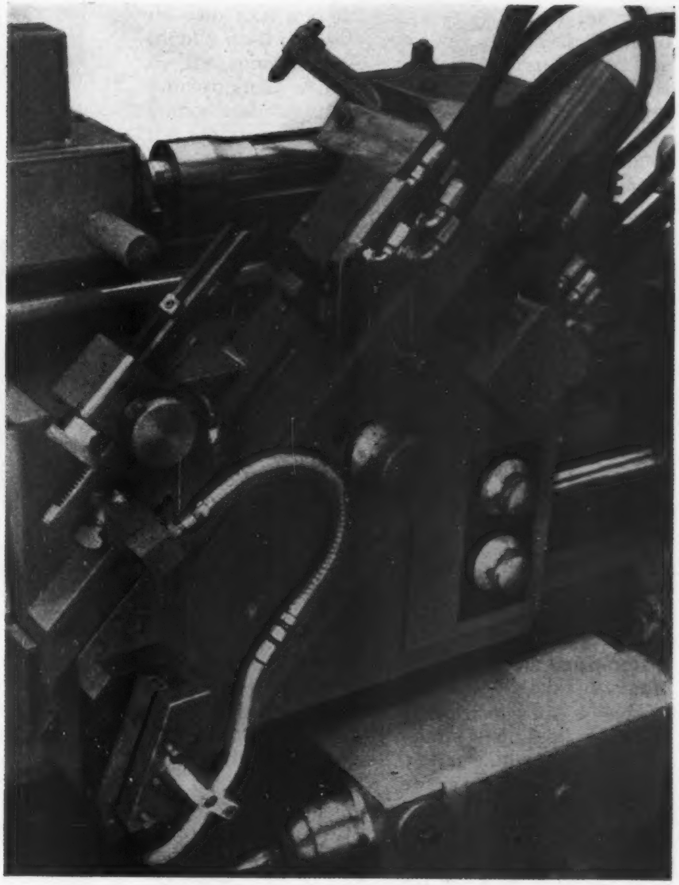


Fig. 42. Copying slide on the P.5 showing the adjustable depth stops and the position of the tracer. Changes in diameter are made by adjusting the dial in the centre.

by means of tripstops and these changes can be made in any one of the four machining cycles. One feed change can be made during the work cycle and operates in conjunction with spindle speed, so that a constant feed rate is maintained.

Model P.5

This machine has been designed on the unit construction principle and is obtainable with two different lengths of bed. The hydraulic copying slide is mounted in the vertical plane at 45° to the machine's centre line. Built into the overhead carriage is a vertical slide carrying the tracer valve and stylus. Adjustment of this slide, by means of a graduated dial, enables diametral adjustment of the cutting tool to be made. For longitudinal adjustment, the slide carrying the template can be moved by means of a micrometer screw.

Hydraulic circuits are controlled electrically either by push buttons which are mounted at the headstock, or on a pendant fitted at the tailstock at the end of the machine.

Automatic recycling is possible with a number of cycles, up to four being selected by means of a rotary switch. After each cycle the template carrier is automatically indexed.

The machine cycle, length of travel of the turning carriage, feed and speed changes, are controlled by adjustable trips mounted on the trip bar which is fitted to the template slide unit; thus if any adjustment is made to the position of the template, it is unnecessary to re-adjust the trips.

The range of headstock speeds is determined by pick-off gears fed at the front of the machine, and an automatic change in ratio of 2 : 1 can be made whilst cutting.

Movement of the carriage is provided by a hydraulic cylinder, oil being pumped through one or other of two flow control valves, giving a high and low feed rate. Once again selection of either feed is controlled by means of trips. Skip feed and rapid return can also be arranged during the cycle.

A full range of loading and unloading equipment is available, together with an automatic chip conveyor, and by the use of this equipment it is possible for two or more machines to be operated entirely automatically, workpieces being transferred from one machine to the next.

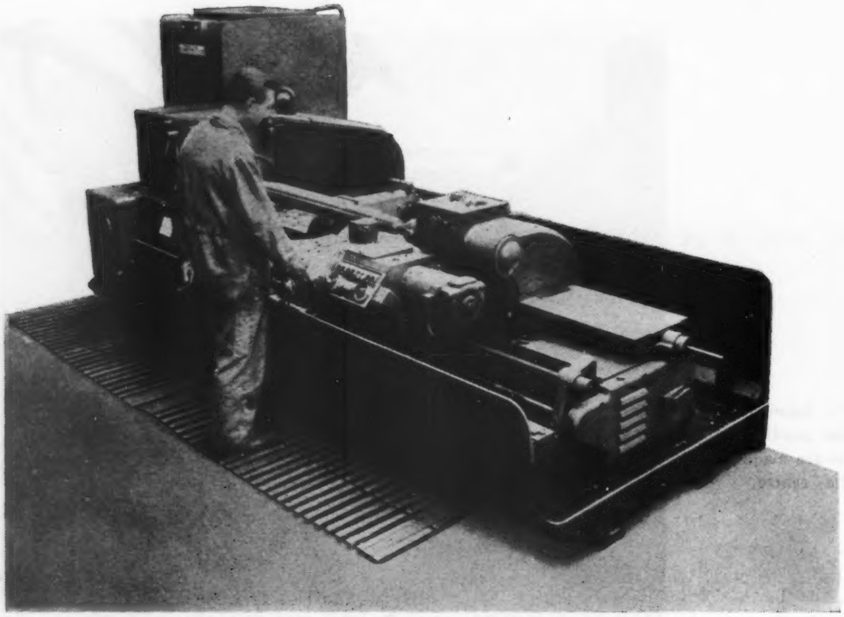


Fig. 43. The Drummond "Maxicut" fitted with the Lancashire Dynamo electronic control system.

Drummond Bros. Ltd.
Maxicut

This is an electrically-controlled machine, the copying slide being mounted horizontally at the front of the machine and at right angles to the workpiece. The template carrier is also mounted at the front and flat or round masters can be used.

The tracer-head, which consists of a coil mounted on the stylus, centrally located between four other coils, controls both the movement of the cross-slide and longitudinal movements of the carriage, both cross-slide and carriage being driven by electrically controlled D.C. motors. Any deflection of the stylus due to contact with the template produces a voltage variation in the fixed coils, which are then analysed and amplified and fed to the respective splitfield generators of a Ward-Leonard set. These in turn supply the variable voltage, of either polarity, to the servo motors driving the carriage and cross-slide.

When the tracer first meets the template it is deflected from its neutral position, and this initial deflection causes a motion that increases the deflection by a predetermined amount. When this full deflection is registered, the motion of the carriage and cross-slide is such that the stylus moves at a tangent to the template (Fig. 45).

An independently controlled rear slide can be used for grooves or bulk metal removal and is adjustable

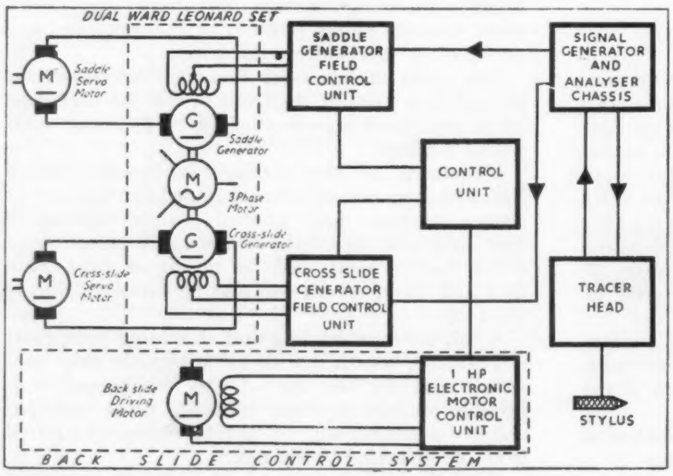


Fig. 44. Block Schematic of the Electronic Profile Following System and ancillary back-slide control.

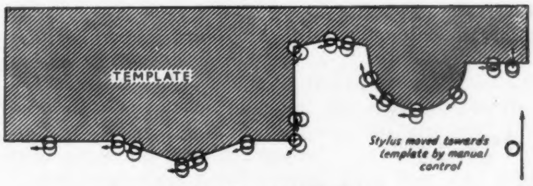


Fig. 45. (See text).

to any position along the bed. A wide range of spindle speeds is available but speeds cannot be changed whilst there is rotation of the spindle. Feed motions are variable between 0 in. - 10 in. per minute.

Maxipilot

This is an automatic multi-cycling hydraulic copying lathe, in which both longitudinal and transverse motions are controlled. Since two-directional control is available, the tool slide is fitted normal to the machine axis.

Transverse motion of the slide is controlled hydraulically by a single edge valve (System II) ; the tracer also controls the longitudinal motion. By reference to Fig. 47 it will be seen that gear G is fixed to the saddle by the support carrying the auxiliary unit FG, and meshes with leadscrew A. It may either be fixed or free to rotate about its own axis. If the gear is locked and not free to turn, it will act as a normal nut system. The leadscrew, however, cannot drive the saddle since it is free to move along its own axis and in so doing will open the valve slightly until the leadscrew feed, which is determined by the spindle drive, and the hydraulic feed are synchronised. Any variation in saddle feed is immediately transmitted to the valve which corrects the variation.

As the tracer scans the template, any movement in the transverse direction causes the slide to move across the saddle, whilst movement in the longitudinal axis, e.g., when a shoulder is reached, is detected by a micro-switch and energises a solenoid controlling the feed brake/clutch, and rotation of the leadscrew stops. In addition, a second electro-magnet in the tracer is energised and closes the transverse motion control valve by a pre-set amount, causing the tool to withdraw until the tracer clears the shoulder.

Transverse and longitudinal feeds, which are variable, are independent of one another. The saddle feed can be changed during the machining cycle in a ratio of 2.5 : 1.

Automatic recycling is possible and is controlled by a programme control drum H, mounted at the end of the indexing stop bar. The eight-position template carrier rotates with the stop bar. The programme control drum is detachable so that complete changes of programme can easily be made. In addition, the trip dogs on the drum are readily adjustable. The drum controls spindle start and stop, feed engagement, feed reduction, template indexing and other auxiliary operations, and is driven by a motor E through a reduction gearbox (Fig. 48).

A further set of micro-switches K is fitted at

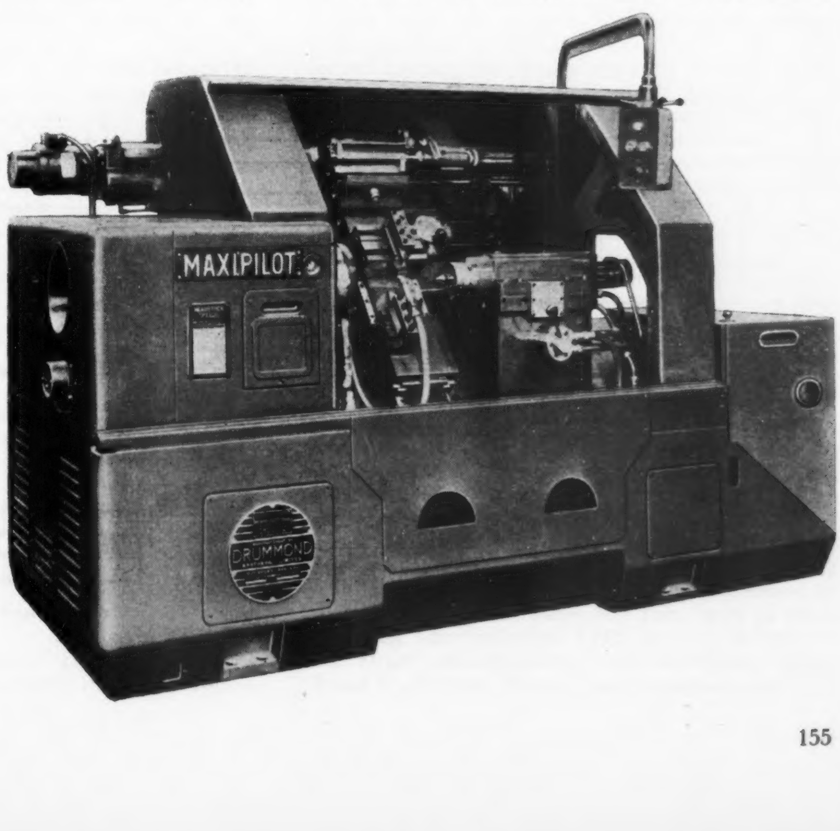


Fig. 46. The Drummond "Maxipilot".

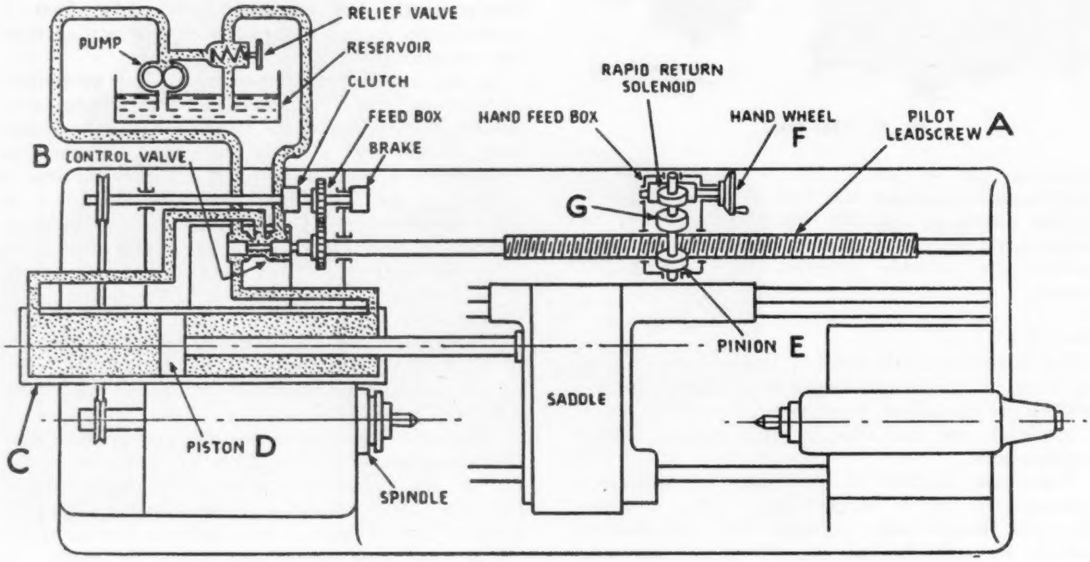


Fig. 47. Hydraulic and mechanical control of longitudinal feed.

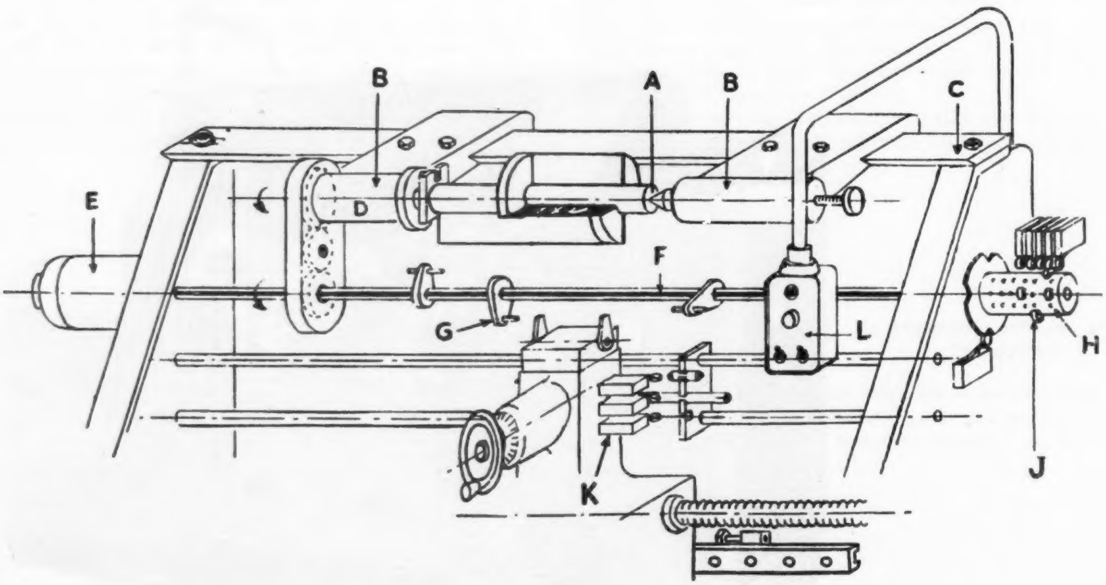


Fig. 48. Multi-cycling system.

the rear of the machine, so that any function selected by the drum control for a given pass can be varied during the cut.

When the saddle contacts the preset longitudinal stop at the end of its pass, the template carrier and stop bar are automatically indexed and the next set of movements initiated.

Auxiliary tools can be fitted on a rear tool post attached to the copying slide and additional overhead tool slides can be fitted if required.

Additional, optional, features are automatic loading and unloading, gauging and control circuits, chip conveyors and two speed main motors.

Alfred Herbert Ltd.

The smaller of the two machines manufactured is known as the "Carbijunior" and is fitted with a hydraulic copying system mounted at the back of the cross-slide at 45° to the machine's centre line.

The larger and more versatile machine is known as the "Carbitracer" and here the copying slide is mounted in a vertical plane at 45° to the machine's centre line. Both flat and round templates can be used.

Forming and grooving slides may be fitted below the work and are manually operated.

A mono-cycle attachment is available which controls the machine through one complete machining cycle and returns the slide to its starting point. If a second cut is required the tool must be reset and the cycle restarted, but the addition of a six-position stop bar assists in taking a number of cuts.

Eight spindle speeds are available and spindle speeds can be changed without stopping the spindle, the ratio of the change being 1.67 : 1. Three feed rates are possible, but changes of feed are not incorporated in the automatic cycle.

Copy turning attachments can be fitted to capstan and turret lathes and are attached to the cross-slide in the position of the rear tool box. Both longitudinal and transverse copying can be undertaken and when being used in transverse copying, the template is carried on a special attachment fitted to one face of the turret.

Fitting of the copying attachment thus does not preclude the use of turret and front tool box for their normal functions, and by using a copying slide the manufacture of many special form tools can be eliminated. It can also be used for the accurate finishing of diameters.

attachments

In addition to the specialised machines described above, a number of hydraulic copying systems are available which can be fitted to existing machines or used in a new design. In the United Kingdom there are four manufacturers of such attachments which are extensively used, and several more are under development.

The four manufacturers are:

1. Associated Electrical Industries (Manchester) Ltd.

who have patented a form of hydraulic potentiometer system which was described in Part I, System II(a). Two models are available, the Junior Monoblock with a maximum thrust of 500 lb., and the Monoblock with a thrust of 1,200 lb (Figs. 49 and 50).

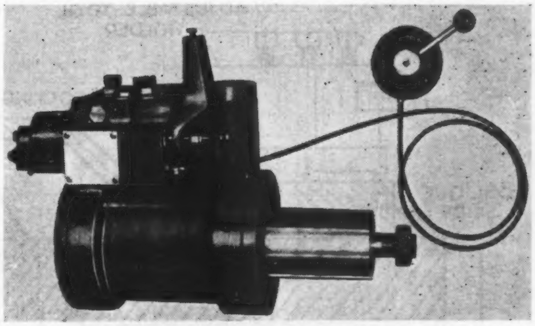


Fig. 49. Mono-block copying unit.

2. Hayes Engineers (Leeds) Ltd.

have used the basic type of system in which a spool valve switches the oil from one side of the piston to the other (System I) (Fig. 51).

3. Hepworth Iron Co. (Engineers) Ltd.

4. S. N. Bridges & Co. Ltd.

have modified System I and the difficulty of sealing the ports has been overcome by the design, which allows face sealing of the spool valve.

This valve, as can be seen from Fig. 52, has a locked or neutral position, when the work resistance cannot affect the copying accuracy as the system is independent of oil pump pressure. In the fully locked position (no flow) there is no overlap of the valve ports as is usual with other copying valves, and all the ports are sealed. This means that there is an instantaneous response to the movement of the stylus N. The valve, which is of a patented design, does not rely on the effect of the difference of pressure supplied to either side of the piston, i.e., the conventional potentiometer effect; thus copying accuracy is not affected by the work resistance to the same degree as in other systems. For the same reason, for any given stylus movement the response and the copying movement is faster. The locked or no flow position is obtained by face sealing and is independent of pump delivery pressure. This means that the system is unaffected by varying pump pressure and does not require a relief valve in the pump unit.

The action of the unit may be seen from Fig. 52. In the over-deflected position (shown by dotted arrows), the tracer pin N, when deflected by the template to the right, depresses plunger A. The valve liner assembly B is forced against valve C, thus sealing the faces at D and E. The difference of the diameter of the valve and liner bore at these points is approximately 0.003 in. The springs V and H are now compressed and interference points F and G are open. The inlet oil pressure points from

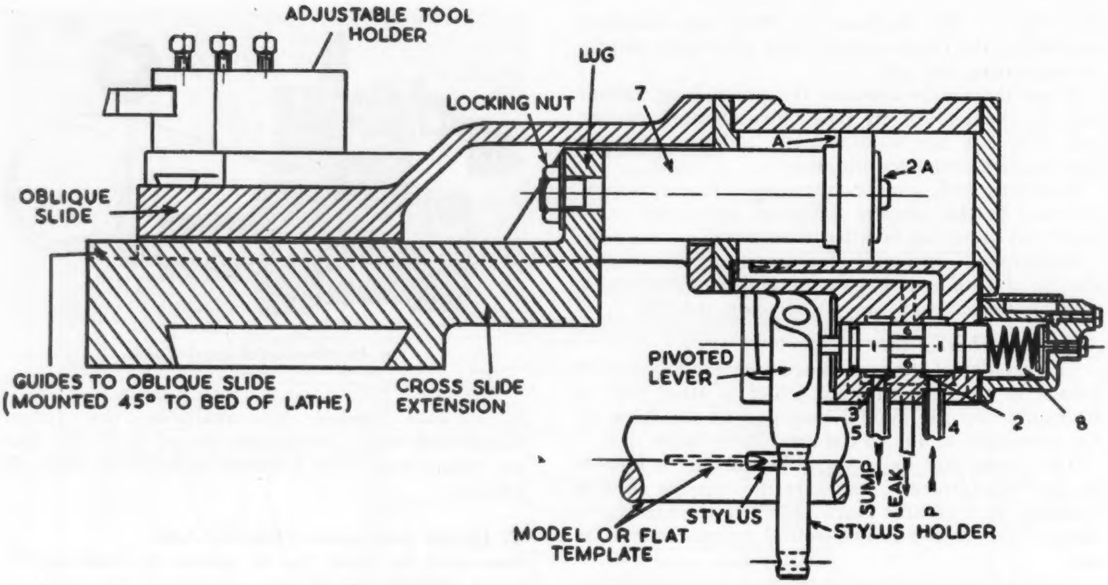


Fig. 50. Diagrammatic view of mono-block copying unit.

pump source are at (b) and (l). Oil now enters through inlet (l) into annulus (a) through G and U to piston face M. The cylinder Q moves to the right. Oil K is displaced through passage Y to port T past F to outlet P. The whole assembly has now moved away to the right, away from the tracer pin N, thus relieving pressure on plunger A.

In the neutral position (no flow), the spring V returns valve liner assembly B, and spring H returns valve V, thus face sealing at F, G, D and E. No further movement takes place and all oil flow ceases, the system now being fully locked.

In the under-deflected position (shown by lined arrow), if it is assumed that the tracer pin N moves slightly to the left then the valve liner assembly B is forced by spring V to the left, thus opening sealing faces at D and E. Oil from the pump now flows through inlet (b) via D, R and Y to piston face L. The cylinder Q moves to the left, and oil is now displaced through U via Z, S and E to outlet P. The whole assembly has now moved to the left towards the tracer pin N and will continue to move until pressure on plunger A forces liner assembly B to the right, thus closing interference points D and E.

Again in the neutral position of no flow, no further movement takes place and all oil flow ceases, the system now being fully locked. Any leakage past

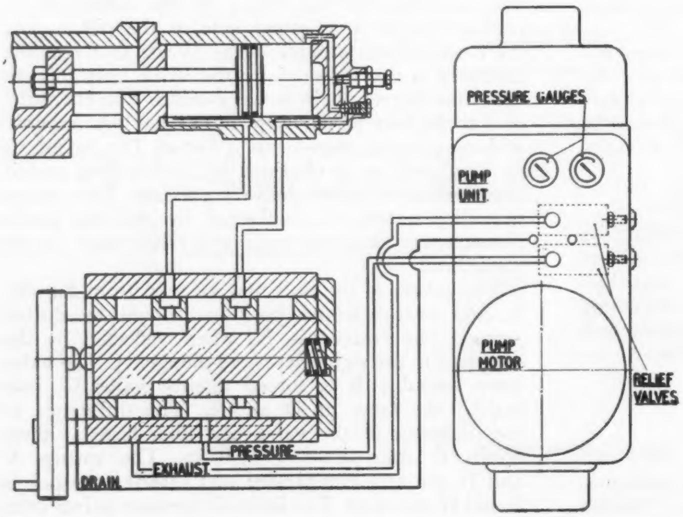


Fig. 51. Hayes control system.

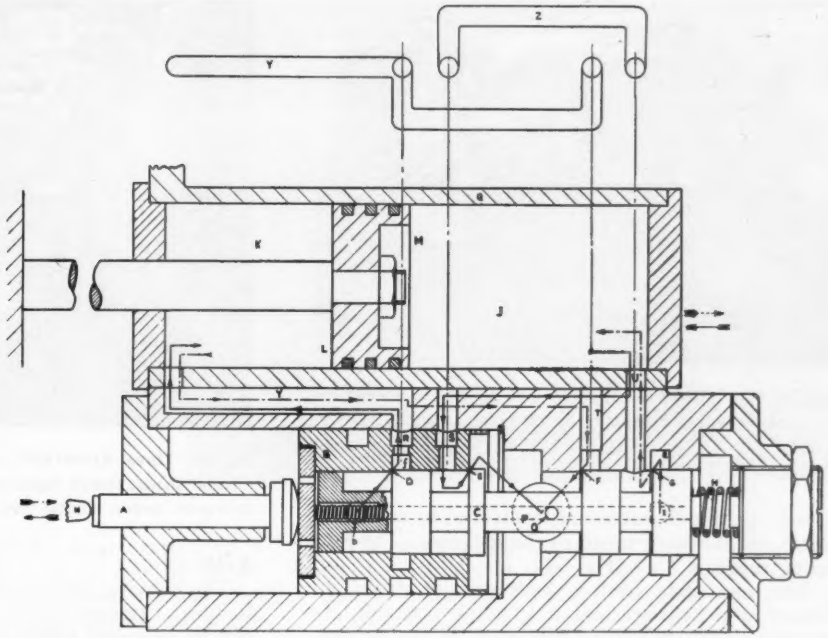


Fig. 52. Bridges control system.

the end glands of valve C passes through the centre bore of the valve through O to outlet P.

Continental machines
E. Dubied & Co., Switzerland.
Agents: *Wickman Ltd., Coventry.*

A number of different machines are produced by this Company, but all models are fitted with hydraulic control of copying slide and saddle feed.

Model 517

The hydraulic copying slide is mounted at 60° to the machine's centre line and travels on an inclined bed at the rear. The tracer is designed according to the " double seat system " to ensure high copying accuracy (Fig. 53).

The machine can complete one cycle automatically and to facilitate operation when more than one cycle is required, six length and depth steps can be fitted. The depth stop barrel indexes automatically after each cycle.

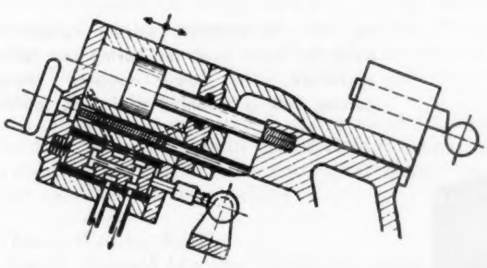


Fig. 53. Hydraulic copying system used on Dubied lathes.

A machine may be fitted with a variety of motors and spindle gear boxes to customers' requirements. The hydraulic feed is infinitely variable and can be controlled to give a constant feed per revolution of the spindle.

Models 514 *and* 515

These two models are slightly smaller than the 517 and they are identical to one another except that 515 is equipped with constant cutting speed control. After initial setting of the required cutting

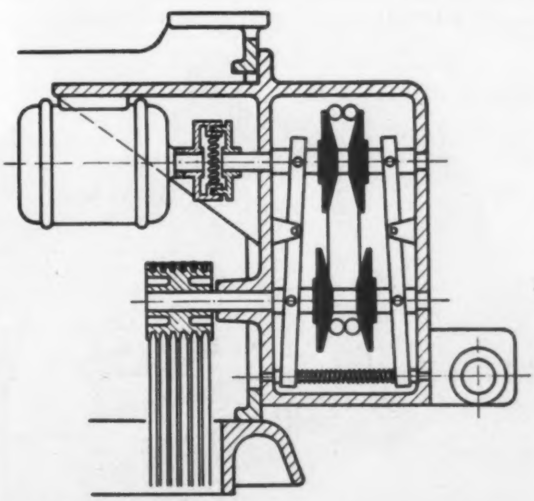


Fig. 54. Constant cutting speed control. The size of the cone pulleys is adjusted by a servo control from the tool slide.

Fig. 55. Two KDM-7 lathes fitted with automatic loading and unloading and connected by conveyor (see Fig. 37).

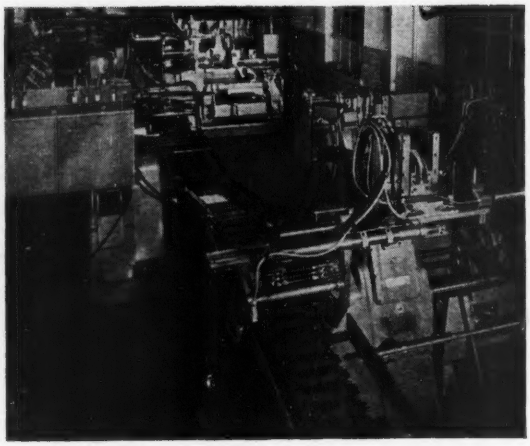


Fig. 56. Three KDM-11/70 machines, for machining transmission shafts, linked together by a fully automatic indexing conveyor, and a shuttle-type loading and unloading device.

speed, the spindle rotation is controlled by an electric servo-mechanism coupled to the tool slide. The total speed range is 7 : 1 (Fig. 54).

The tool slide feed is hydraulically driven by means of a cylinder and is infinitely variable. To provide optimum cutting efficiency, it can be controlled to give a constant feed per revolution of the spindle.

The copying slide and template are fitted on an inclined bar at the front of the machine at 45°.

Length and depth stops are fitted as on the 517 and can be used in conjunction with the automatic return.

George Fischer & Co. Ltd., Switzerland.

Agent: Vaughan Associates, London, W.1.

A wide variety of machine capacities are available in the + GF + range and these are based on two models, the smaller being KDM-7 and the larger KDM-18 with a number of variations.

KDM-7

The copying slide on the KDM-7 is carried on an inclined carriage above the work centre line and can be swivelled either into the vertical position or at 60° to the axis of rotation. Only the motion of the copying slide is controlled by the tracer, which is of the hydraulic potentiometer type (System II(a)). The template holder, which is carried on a special rail above the copying slide, has micrometer adjustment to ensure that the template or model is properly aligned. A number of recessing slides, which can be either manually or hydraulically operated, can be fitted to the front accessory support.

Certain changes of feed are possible on the standard machines, but both feed halving and skip feed are possible in any part of the cycle and are controlled by adjustable stops. As supplementary equipment, a six-cut recycling device is available,

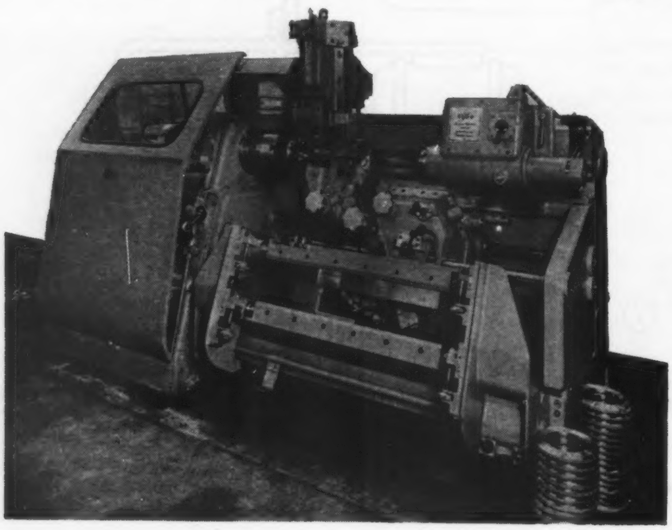


Fig. 57. A KDM-11 (smaller version of KDM-18) being used for boring and facing operations. The power-operated plunge cutting slide is mounted above the spindle.

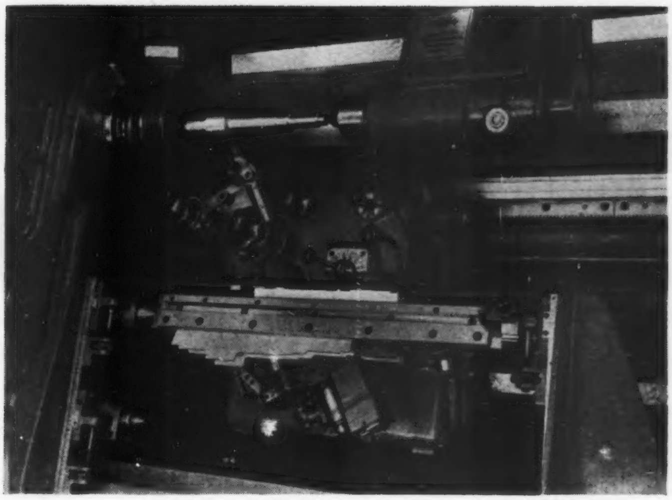


Fig. 58. A KDM-18 machine with two-way swivelling template.

the cycles being controlled by dogs carried on a rotating drum. The control drum can be preset, away from the machine, and controls not only the feed halving and skip feed cycles but also the length of parallel cuts; the depth of cut being controlled by a set of stops, which may be necessary before a template is used.

In addition, where the recycling device is fitted an automatic swivelling template holder can be used, and this allows workpieces to be profile turned automatically and, in addition, it is possible by using suitable handling devices to connect several machines together and thus form an automatic production line (Figs. 55 and 56).

KDM-18

The KDM-18 is available with three-cut recycling and a two-way swivelling template holder. Attached to the template holder is a feed control template, which automatically engages at the appropriate position, the feed, half feed, or skip feed as desired; a separate feed control template being fitted for each workpiece template (Fig. 58).

Complete control of the machine can be accomplished by means of the automatic programme control in which the tool motions are preselected by means of electrical switches, and each machine motion started by micro-switches, sliding over dogs mounted on the programme control rails. Independent operation of the various movements is possible by means of push buttons, and these are useful for setting-up purposes.

Constant cutting speed is approximated by means of the automatic spindle speed change which has a range of six steps. Three groups of spindle speeds are available on the machine.

Hasse-Wrede, Berlin.

***Agent*: *Benrath Machine Tools Ltd., Manchester*, 22**

Three hydraulic copying units are available for fitting to the range of heavy duty production lathes built by this Company.

The copying slide is mounted at 60° to the centre line horizontally at the rear of the machine, and a tracer can be fitted to scan the template mounted either above or below the machine bed. The position of the template, which can be either flat or round, depends on what additional attachments are fitted.

The front tool post is used for parallel roughing cuts and recessing. When parallel cuts are being taken, six preset length and depth stops can be used (Fig. 60).

Fig. 59. Duplex copying (see Fig. 39).

Fig. 60. Hasse & Wrede lathe fitted with semi-automatic control of copying slide and threading attachment.

Electric semi-automatic control may be fitted which can control parallel turning, copying and thread cutting.

H. Ernault-Batignoles, France.
Agent: Drummond-Asquith (Sales) Ltd., Birmingham, 2.

In addition to a range of hydraulic copying units which can be built into the companies HN and AC series of lathes, there are a number of automatic and semi-automatic machines which are capable of undertaking most copying operations.

OP 320 *and* 420

These machines are fitted with two-dimensional control and hence the copying slide is fitted at 90° to the machine axis, at the rear; the lateral traverse motion of the copying slide is controlled by a hydraulic spool valve, whilst the longitudinal motion of the saddle is controlled by a micro-switch incorporated in the tracer.

When the tracer meets a steep slope, which cannot be followed by movement of the cross-slide alone, the micro-switch is depressed, this in turn causes two electromagnets to be energised: the first electric magnet controls the preset depression of the hydraulic valve and thus the movement of the cross slide, and the second causes the feed shaft to become disengaged from the saddle until the steep slope or shoulder is cleared. By this means accuracies better than .001 in. on diameter and .002 in. on length can be obtained. The hydraulically controlled cross-slide uses the differential pressure system of operation (System II). Travel of both the cross-slide and the saddle can be controlled by means of adjustable stops.

The system used is as described for the Maxipilot (Fig. 46).

Tools for copying are fitted at the rear, the tool post being mounted in a series of "T" slots which allow the tools to be preset and also to be mounted in a variety of positions. These "T" slots run across the full length of the cross slide and tools for roughing or recessing are mounted at the front.

Spindle speeds and feeds are changed by the use of pick-off gears. Automatic feed change in the ratio of 3.5 : 1 can be made whilst cutting is in process.

Specially adapted from the OP 420 is the OP 420 GT, which has been designed for the manufacture of circular moulds and dies.

To achieve this end the master is rotated at the same speed as the work, and to ensure faithful copying it is necessary to see that the distance between the master and the workpiece is identical to that between the tracer and tool point.

In addition to transverse copying for dies, longitudinal copying with a rotating master can be used for the manufacture of non-circular punches, and similar components.

For normal copying the tool and tracer are pointing in the same direction but by reversing the position of the tracer it is then possible to produce a male workpiece from a female master, or *vice versa*. By this means a complete tool set can be produced either from a master or an existing part.

A much wider range of spindle speed is obviously necessary on such a machine and 64 speeds are available ranging from 1.5 to 2.400 r.p.m., together with a wide range of feeds.

S. Pilote

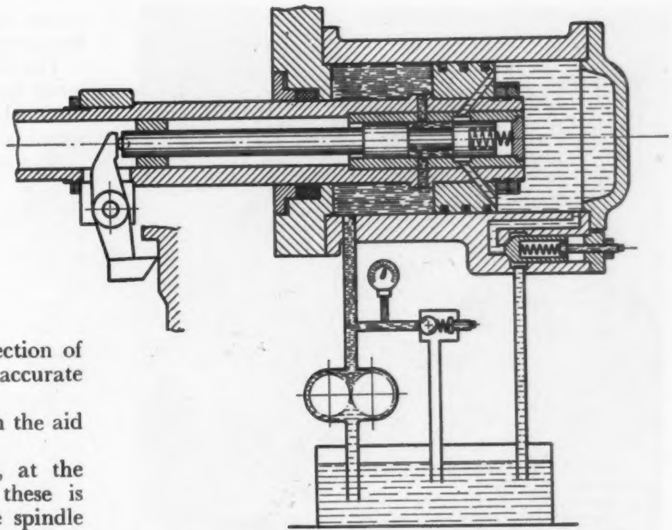
The S. Pilote has been designed for the user who is required to manufacture parts in small and medium batches on a repetitive basis.

Any unit of the machine, the position of which has to be changed, is provided with reference points, i.e., graduated scales or dials, so that provided the information for one set up has been recorded it may easily be reset.

The copying slide is set normal to the work centre line since two-dimensional control is fitted.

Up to four-cut recycling is possible and all machining cycles are taken under template control. The depth of cut for each pass can be preselected on a dial. By having all cuts following the template, a difficulty which may occur when parallel roughing cuts are taken is overcome. This difficulty is that if parallel cuts are taken the final cut, under tracer

Fig. 61. The Heyligenstaedt copying unit.



control, will be of varying depth and deflection of the workpiece may occur, thus preventing accurate copying.

Longitudinal stops can be easily reset with the aid of a built-in tape measure.

Infeed slides may be fitted if required, at the front of the machine, and the feed of these is readily adjustable and is controlled by the spindle speed. Accurate machined diameters are obtained by adjusting the slide so that the operating piston comes up against the end of the cylinder, which acts as a stop; rapid approach and dwell are obtainable in the cycle.

Different spindle speeds may be selected by manual operation of the gear box and the speed groups may be changed by means of pick-off gears. Feed changes may be made whilst cutting and may be changed in a ratio of 2.5 : 1. In addition skip feed and feed reversal may be engaged. Feed reversal is used for copying opposed square shoulders with a duplex tool attachment.

Automatic control of the machine is through the use of two punched cards, one card controlling the feed and spindle rotation, whilst the second controls the position and effective length of each operation. The length of each operation is determined by the length of the slot cut in the card.

Heyligenstaedt & Co., Germany.

Agent: *Burton, Griffiths & Co. Ltd., Birmingham*, 33.

Two basic ranges of machines are manufactured, the Heycop production copying lathes, and the Heycomat which can be obtained with a fully automatic cycle.

Heycop

The Heycop 1, 2 and 3 are production lathes of coventional layout with the copy slides set at 60° at the rear of the bed, the tool box being fitted in front of the workpiece. The hydraulic copying system is controlled by a single edge tracer valve (System II(b)) which is built into the slide piston.

Additional slides may be mounted on a supplementary rail and manually operated (Fig. 61).

The semi-automatic cycle, which gives an automatic return of the saddle, can be used and longitudinal travel is controlled by preset stops which can also introduce feed halving at any desired position. Depth of cuts is preselected on a calibrated dial, to the rim of which are fitted dogs corresponding to the individual depths of the cut; up to four cuts may be taken, the last being under tracer control.

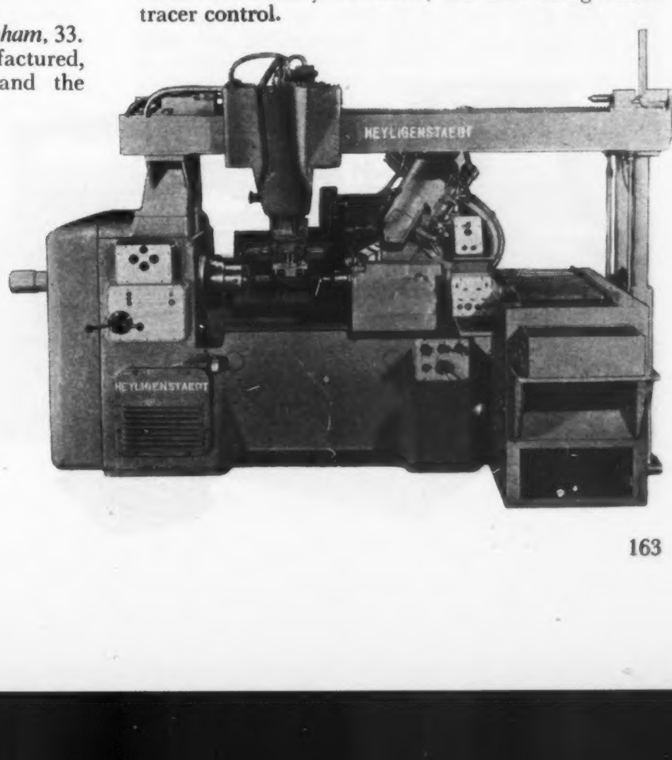


Fig. 62. A Heycomat 2 fitted with automatic loading and unloading from an indexing conveyor.

Fig. 63. Copying slide with tools fitted for internal and external copying at one set-up. Rotating stop bar for depth control is fitted on the right of the slide.

Speeds and feeds are changed by means of manually-operated gear boxes, and in addition, feed halving which can be hand as well as automatically controlled, is achieved within the feed box by an electromagnetic clutch.

A range of machines similar to the Heycop 1, 2 and 3 is the 1u, 2u and 3u, the difference being that they have the full facilities of a centre lathe and as a lead screw is fitted, feed halving and rapid return of the saddle are not available.

Heycomat 2 and 3

The Heycomat 2 and 3 are similar machines, the latter having a larger capacity. The special version of the Heycomat 2 is produced with an increased spindle diameter.

A similar copying mechanism is used as on the Heycop range and is mounted above the workpiece, the slide being at an angle of 60° to the machine centre line. As the slide has a long travel these machines are very suitable for copy facing, and in addition, to facilitate this they have a fairly large capacity over the bed. Both round and flat masters can be fitted and the master carrier is adjustable for setting purposes. Auxiliary slides may be fitted to the front of the machine.

Automatic cycles can be programmed by means of trip stops and when fitted with the six-cut cycle, the control enables four cylindrical cuts to be taken, followed by a single roughing and finishing cut under tracer control (Fig. 63).

In addition to multi-cycling automatic change of speeds and feeds can be incorporated, speeds being arranged in eight basic steps; within each step three speeds may be selected within any machining cycle. The feed rate is controlled by a P.I.V. gear and can be changed over a maximum ratio of 1 : 8. For each machine cycle, three feeds independent of one another can be selected and changed under load, each change being initiated by adjustable stops. In addition, skip feed and rapid return are incorporated.

Loewe & Co., Berlin.

Agent: George H. Alexander, Birmingham, 4.

DZ 508

This copying lathe is built along conventional lines with the copying slide set horizontally at the rear, at 45° to the work. Single edge hydraulic tracer is used in the hydraulic copying system, the templates being fitted above the copying slide, and the front tool post being used for recessing or rough turning (Fig. 64).

Semi-automatic control may be fitted as an extra

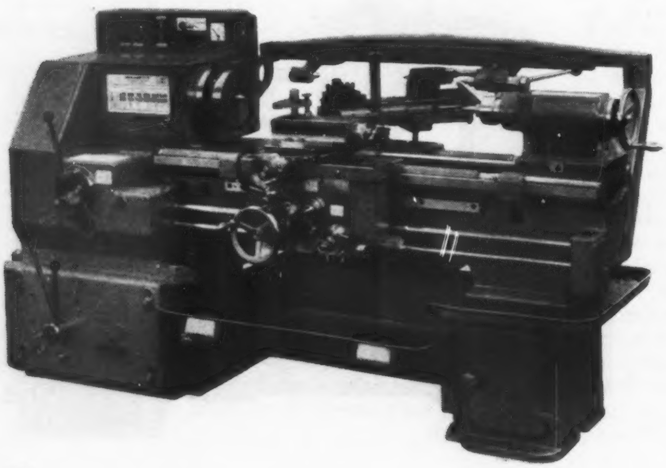


Fig. 64. Loewe DZ 508.

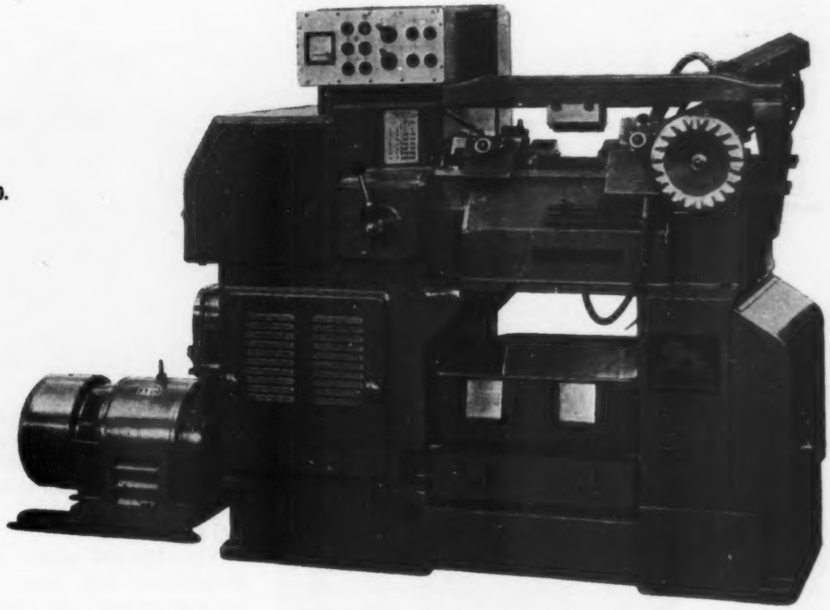


Fig. 65. Loewe DA 150.

and causes the copying slide to retract and the saddle to return to the starting point. A single speed change may be made whilst cutting; the feed, which is infinitely variable over a ratio of 8 : 1, may also be changed.

DA 150

Either semi- or fully-automatic control may be obtained for this machine which is designed mainly for facing and short centre work (Fig. 65).

Two bedways can carry either copying slides, working on the same principle as the DZ 508, or plunge cutting slides.

With fully automatic control three successive cuts can be taken in conjunction with changes of spindle speed and slide feed.

Power-operated work holding devices enable automatic loading and unloading to be completed.

Max Müller Ltd., Germany.

***Agent*: *Henry Pels & Co. Ltd., London, N.W.*1.**

The use of unit construction enables a full range of machines to be built up with the minimum variation in units. Specialised machines are also readily available.

Basically the AM series is for turning whilst the TM series is for facing work. A range of front turning machines is also available.

AM and TM Series

The full value of these machines is fully realised when equipped with the "Eltropilot" control system, which enables the machine to be controlled completely automatically.

Two-directional control of the lathe is possible with the "Eltropilot" in addition to the normal functions of speed and feed changes, operation of auxiliary slides, etc. (Fig. 67).

All machine motions are preplanned and trip plates are set up; this may be carried out away from the machine, the trips being set in position in accordance with the positions at which changes in machine movements are required. Fine positional control is by micrometer adjustment of the microswitches which engage the trips. The control orders

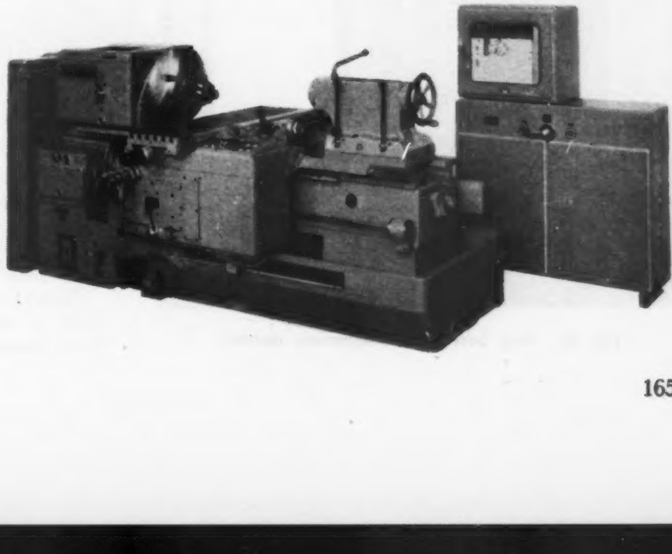


Fig. 66. A series AME lathe fitted with Eltropilot control.

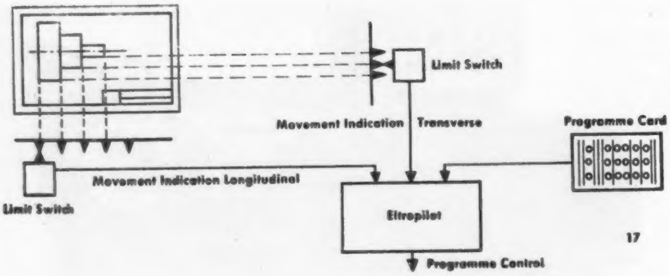


Fig. 67. Block diagram of the Eltropilot control system.

are by means of a plug board and in order to facilitate the setting up of the plug board a programme card, the same size as the plug board, is punched in the required positions and used as a mask over the plug board when inserting the plugs (Fig. 68).

The "Eltropilot" control will only produce surfaces either parallel, normal or at 45° to the machine axis and for other shaped surfaces the copying attachment is used. This is fitted to the cross-slide table and may be used for sliding or surfacing and the copying slide is hydraulically controlled by a single edge valve. An additional facility is for a feedback link between the copying slide and the feed control to be used to keep the effective feed constant at a predetermined value.

Machines fitted with "Eltropilot" control can also have the advantage of constant cutting speed, the total speed range being 7 : 1. The method of speed control is to vary the armature voltage and field current to the D.C. shunt wound driving motor.

Up to four on-load speed changes may be accomplished on machines not fitted with the automatic control system, by means of a pre-selector switch and push button control. Feed changes are made through a manual or automatic control gear box.

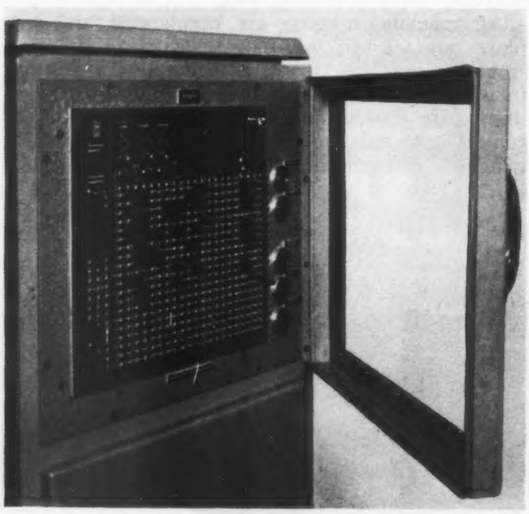


Fig. 68. Plug board for programme control.

The use of a flat table type cross-slide enables tooling to be preset away from the machine and the "T" slots allow for easy adjustment of the tool blocks. Powered tool slides may be fitted if required. (Fig. 69).

FD 500

The FD 500 series of front turning machines enables very high rates of production to be achieved on ring or disc type components. Two inclined beds running parallel to the spindle axis carry two independent slides. Motions of the slides are hydraulically powered and trips allow positional accuracies of .0004 in. to be maintained. Feeds are infinitely variable and three feeds may be used, on both slides, on any one set-up (Fig. 70).

Where the workpiece is contoured a copying slide can be fitted on either bed.

"Eltropilot" control may be fitted to both slides, one control board being a master unit and the other acting as a slave unit.

To facilitate the high rates of production possible, automatic loading and unloading with power clamping may be built into the control cycle.

Maxnovo Co. Ltd., Italy.

Agent: *Catmur Machine Tool Corporation Ltd., London, W.*11.

"Profilomatic" duplicating systems may be fitted to many types of machine tools and this system forms the basis of a new range of copying machines which has recently been introduced.

Two basic size ranges are available, the MEC 22 with a nominal swing of 16 in. and a spindle motor of 10 - 18 h.p., and the MEC 25 which is slightly larger with a 20 in. swing and 20 - 25 h.p. motor. Various bed lengths and attachments are available and these may be built into a variety of machines according to the unit construction principles used.

MEC 22

This range of lathes is of conventional layout with the copying slide mounted horizontally at the front of the machine at 45° and the tracer mounted at the rear. Tool posts may be fitted at the back of the cross slide for recessing purposes (Fig. 71).

Variations of the basic machine are models which have a fully automatic cycle including speed and feed changes under load.

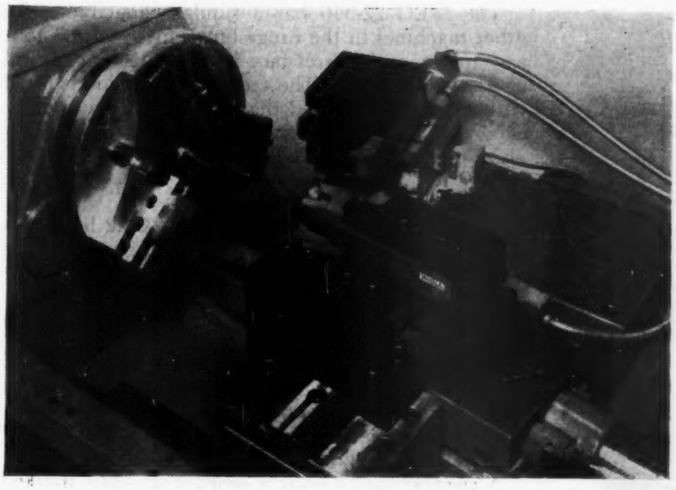


Fig. 69 (left). Preset power-operated tool blocks.

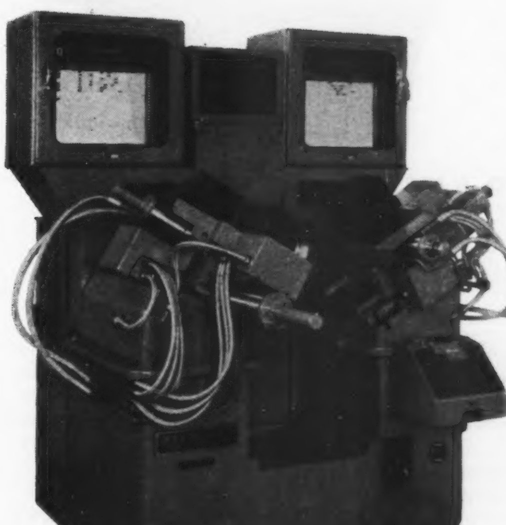


Fig. 70 (right). The F.D.500 front turning lathe fitted with Eltropilot control to both slides. The right-hand control is a slave unit to the one on the left.

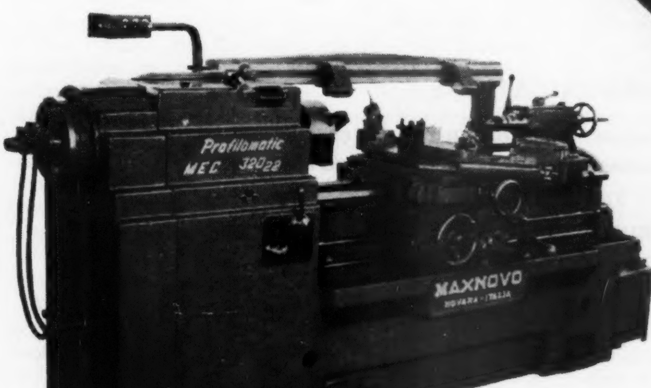


Fig. 71 (left). Maxnovo MEC 22.

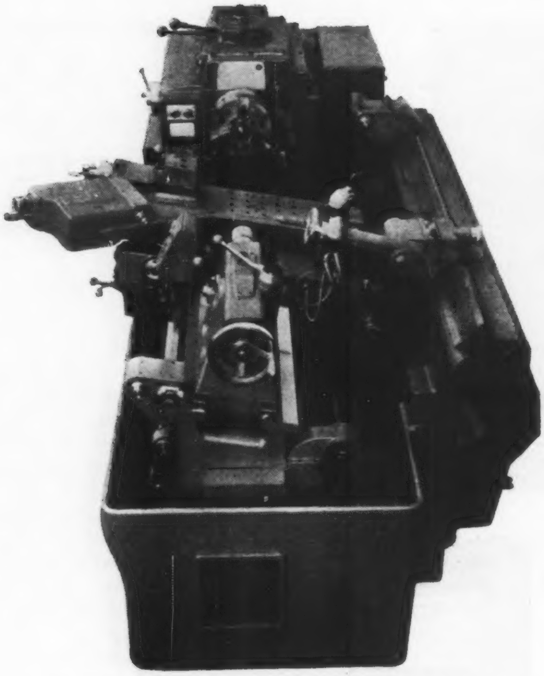


Fig. 72. A MEC 25-311 copying lathe with semi-automatic control.

The MEC 22-340 has a similar capacity to the other machines in the range but is fitted with a four way turret, each turret face being under the control of its own template. The cross copying slide is fitted with multiple stops and the turret can be automatically clamped and unclamped. This machine may also be fitted with a fully automatic cycle.

MEC 25

This is of similar layout to the MEC 22 but has a slightly larger capacity. The copying slide is mounted on an inclined bed at the front of the machine and at an angle of 60° to the work (Fig. 72).

Automatic loading and unloading may be fitted to both ranges of machines.

Telephotomation

A punched card control system known as "Telephotomation" can be fitted to control automatically all machine functions.

A circular card having a series of six holes marked on radial lines is fitted to a rotating disc. The desired machine cycle is selected by punching holes in the card, a binary code being used, and cycle control is obtained through a set of photo-electric cells placed behind the card, each cell corresponding to the position of the six radial holes. The timing of each function is controlled by a rotary "time" disc. After completion of the machine cycle both the "time" disc and the punched card return to the starting position.

TO BE CONCLUDED

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THE EDITOR,
THE PRODUCTION ENGINEER,
10 CHESTERFIELD STREET, MAYFAIR, LONDON, W.1.

MECHANISATION OF OLD-ESTABLISHED INDUSTRIES

A Thesis by W. TEARNE, A.M.I.Prod.E.

Plant Development Engineer,
Development Division
Dunlop Rubber Co. Ltd., Birmingham.

MOST factories which have been built during and since the Second World War, and even between the Wars, were created or developed with the idea of mechanisation in the background. These are, however, a small number when compared with the factories in existence in 1920 or earlier. Some of these old industries, through receiving new blood on the boards of directors, or being taken over by larger and more modern concerns, have been revolutionised and mechanised out of all recognition. Others remain, run by the same families, perhaps after three or four generations, using the same traditional methods. They can be likened to some civil servants, whose modest income was once quite sufficient for their needs, but who find the rising cost of living driving them, in their old age, to seek other means of support. This Thesis attempts to give, in terms general enough to apply to any industry, a few guiding principles for those who have undertaken the task of mechanising one of these concerns.

A list of acknowledgments of sources of information is given on page 176, together with suggested books for further study.

tradition and dogma in industry

The expression "old-established industries" is intended to mean those industries which are old enough to have developed their own traditions in the spheres of production, management, distribution and such. These traditions are very often a barrier to progress, as was the case even in ancient Greece and Egypt.

About 1,500 B.C. there were already apprenticeships for the education of engineers. Experience was carefully written down and in many cases became a dogma, which hindered further progress for a considerable time. Because most engineering knowledge was held by a kind of priesthood, it was unthinkable to depart from methods laid down by the old masters. Similarly today, there are places of industry where tradition and dogma are allowed to rule the lives of the workers and sometimes the management. A production engineer who has been given the task of improving, by mechanisation or any other means, a business of this kind, has a formidable array of problems to solve.

the decision is made

Pressure of circumstances is usually the reason why managements decide on mechanisation as a definite policy. It may be that sales have dropped due to undercutting of prices by more efficient competitors, and production costs must be reduced. Alternatively, a continuous increase in demand may have made it necessary to improve the potential

output of the factory. Sometimes a decline in the quality of the available skilled labour forces a firm to change to machine-made products, or a shortage of labour of all kinds could make mechanisation imperative. Another incentive is the rising cost of labour compared with that of materials. These circumstances bring the management to the point of considering work study, mechanisation, research, automation, flow production, and other modern conceptions.

the man is chosen

Let us assume that a production engineer is to be appointed by the Managing Director, with instructions to multiply output by five, without spending too much of the firm's capital reserves or causing a revolution or strike in the factory. At first sight, this may seem a superhuman task, but then some engineers are apparently superhuman. The earliest recorded production engineer, Enene of Egypt (1500 B.C.) writes of himself, in his own epitaph :-

" I was the highest director of every work, all workshops were under my orders. The overseers acted for me, I made up the accounts. I was great beyond all conception, I was always powerful in peace, and had no misfortunes. My years were passed in happiness. I was no traitor and no shirker, and I never did wrong. I was the overseer of all overseers, and made no mistakes."

Such a paragon of virtues would make the perfect production engineer of the present time, but would be very hard to find. Nevertheless, whoever undertook the assignment in question would have to be given some, at least, of the conditions under which Enene operated. For instance, he would have to be " director of every work ", and all workshops would have to be under his orders. Although he would not be expected to " make up the accounts " he would need to have a very clear grasp of costs of all kinds. It would of course, be very helpful if he " made no mistakes ", but that perhaps would be asking too much.

he faces his problems

The first step our production engineer must take is to enumerate his problems, which can be classified and then attacked in a systematic way. The following is a suggested list of categories :-

1. *economical*
2. *psychological*
3. *material*
4. *technical*

1. economical

Under the heading of economical problems we have to consider the overall financial position of the firm. The amount of capital available for development is the first item to be ascertained, as this controls all future planning. Another factor is the time allowed for repayment of investment out of increased turnover. These two points will be decided by the directors in consultation with the accountants, but it may be possible to increase both capital allocation and time for repayment, if final investigation proves this to be judicial.

Given a capital sum to spend, and an annual saving to achieve, the production engineer has his weapon and his target.

The next step is to draw up a table of output quantities that will achieve the desired object. For instance, if the average profit at present is £60 per 1,000 articles, annual output 1,000,000 articles, then the present profit of £60,000 per annum is the starting point for savings. On the basis of our hypothetical case, the instruction is to aim at a target of 5,000,000 articles per annum. Such an enormous increase in production obviously requires a large capital outlay, but the application of this must be balanced between improved plant and improved methods of using the plant; in other words, better productivity. The famous Alfred Krupp, of Essen, once wrote :-

" Nothing exists, no work of man, which is not capable of, and in need of, endless improvement."

This applies quite as much to methods as to machines.

2. psychological problems

The psychological problems include the selection—from existing staff where possible—and subsequent training of the personnel to undertake the new duties created by mechanisation. The foremen, chargehands and superintendents under the old system would not be able to take over the new organisation without some preparation, so a period of education will be necessary for most of them. There are also cases where an old retainer has been filling a post specially created for him, and which cannot be justified under the new regime. The question of retirement on pension or transfer to more useful work will have to be considered.

With regard to the kind of staff organisation, it is better in a mechanised factory to adopt the " functional " system, rather than the old-fashioned " military " system which grew out of the early family concerns. The " functional " system avoids many of the conflicts and jealousies found in old-established businesses. Instead of the head of each department being responsible for every activity, there will be a specialist, or expert, in charge of each function throughout the factory organisation. For instance, all materials handling would be controlled by a Materials Handling Engineer, who would have his representatives in each department, working under the instructions of the departmental manager. The Materials Handling Engineer would be responsible for purchasing, installing, maintaining and adapting any equipment covered by his function, in any part of the factory. In the same way, the Plant Engineer, the Factory Maintenance Engineer, the Planning Engineer (or Production Engineer), Chief Designer and others, would each be effective wherever their respective functions applied.

Overall control will naturally remain in the hands of the Managing Director, but instead of the periodical meetings with heads of departments,

each claiming to be more efficient than the others, he will become chairman of a committee of experts, each reporting progress and putting forward proposals which could apply to several departments simultaneously. The various managers concerned would be present to give their views and help the discussions.

The selection of personnel for these functional posts must be by suitability rather than seniority of service, as in the old organisation. Loyalty and long service should be rewarded in other ways. As with the heads of departments and functions, all grades of staff and operatives, if not found amongst available personnel, must be introduced tactfully from outside. Where a newcomer is to be in authority over old employees, his superiority in ability and knowledge of his job should be quite clear, if jealousy and lack of co-operation are to be avoided.

3. material problems

The material problems facing the production engineer in his survey include such ponderables as the size and present layout of the factory, availability of road and rail transport, and water, electricity and other services.

Almost certainly, room will be needed for immediate or future expansion, either at the present site or some selected location.

4. technical problems

The technical problems, concerned with methods of production, processes and design, will be dealt with in detail later on.

he looks ahead

Before any detailed survey is made of present conditions, the future must be very clearly envisaged. There should be firm ground for assuming that the vast output, now called for, will still be wanted in 5 or 10 years' time, when the new state of things will be in full swing. If there is not, then some alternative products must be held in readiness to keep the organisation going. Sales or market research is necessary to decide which productions are to be stepped up and which abandoned, whether to limit the range of designs and standardise, or adopt greater variety.

Each industry must make its own decisions, bearing in mind that "Good judgment is based on *all* the facts".

he examines the present

After the main foundations of the future programme — capital, time, and product — have been laid, then the production engineer can turn to the more practical side of his job — how to achieve his target.

First, the present equipment and methods of production must be studied very carefully in every aspect. Time and motion study, job evaluation, investigation of methods of payment and incentives — all these will be called into use at some time or another, and in varying degrees. As the object of this Thesis is to give general guidance only, it will be assumed that this research will be carried out as thoroughly as possible, and in the correct manner to suit the particular industry.

The following are suggested headings for survey reports :-

Name and reference number of operation; Description of operation; Type of equipment; Number of units of equipment; Number of operators; Rate of payment; Degree of skill required; Output per unit per minute, hour, day, week and year; Length of runs or size of batches; Setting-up time; Running cost of machine; Material handling equipment involved, etc.

When every operation in the organisation, from receiving the order to receiving final payment, has been examined, then the "bird's eye" view can be taken, with the object of placing each single unit in its correct place in the scales of cost, sequence and importance.

anomalies are removed

To achieve the ideal in efficiency and high productivity, the following anomalies will have to be eliminated :-

1. Unnecessary operations
2. Bottleneck operations
3. Laborious operations.

1. unnecessary operations

Every item of activity should be impartially scrutinised to ensure that it is vital to the end product. An example of unnecessary work was discovered when mechanising the "making" of earthenware cups. On examining the old-established practice, using the motor-driven "jolley", it was noticed that the "maker" after roughly measuring off a lump of clay, threw it with some force into the mould. A machine which could slap a lump of clay accurately into the centre of the mould would have been very expensive, so an experiment was made on a series of cups, the operator being told to place the clay gently in the mould. The cups so produced were found to be exactly as standard.

Also, the time-honoured practice of "dunting" the lump with the thumb before spinning, was proved to be superfluous. As a result of these experiments, not only was the older method speeded up, but the final automatic machine was much more simple and less costly than had been expected. Many handling operations can be classed as unnecessary, especially when they are due to bad plant layout and lack of planning.

2. bottleneck operations

These are the "headaches" of the production manager's life. Hold-ups in production tend to occur repeatedly at the same places in a series of processes, which can be quickly identified. Sometimes a single machine is handling all the output of the factory, and is working at its absolute limit. A breakdown in a case like this causes a pile-up of work at one point and a slowing-down in all subsequent departments. The remedy here is to use two or more machines,

possibly of lower individual capacity. Then, when one machine is being overhauled or repaired, production is only halved, and when production is intentionally reduced, only a small unit need be in use instead of a large one. Another cause of hold-ups is scarcity of skilled labour for some critical stage of manufacture. Here the Work Study men will be able to give valuable assistance in deciding how to make a skilled job unskilled. Craftsmen's very skill sometimes acts as a bar to progress, as the management tend to lean on their ability to guess the temperature of a piece of steel by its colour, or to tell by the feel whether a piece of cotton is sticky enough.

Machines are usually limited to the imitation of the physical movements of operators, but the addition of electronic devices can produce a machine that has judgment, at least enough for its own needs.

A third cause of stoppages is variation in quality of materials, and also in tools. The obvious remedy for this kind of hold-up is to institute a thorough inspection programme, covering everything that comes into the premises, from nuts and bolts that might have faulty threads, to paper and string that could break and cause loss in transit. During the review of materials, research should be carried out with the object of substituting, wherever possible, cheaper or more adaptable materials. In this connection it is relevant to point out the advantage of visiting works belonging to entirely different industries. For instance, the older industries of pottery and ceramics can learn much from the modern methods used in producing plastics. Research associations exist for investigation of materials and their behaviour in such industries as cotton, rubber, wool, silk, cast iron and plastics, and their reports may give a lead to new ways of producing more goods at less cost.

Many other causes of stoppage can be discovered, but most of them — such as strikes, wrong instructions, etc., are outside the scope of this Thesis.

3. *laborious operations*

Wherever muscular power is used, there is a possibility of reduced output through strain, accidents, exhaustion, absenteeism and high turnover of labour. All movements of workers should be carefully examined and wasteful actions eliminated. In one factory it was found that all the trolleys used for transporting material between machines were only 18 in. high, while the machines themselves were all 3 ft. high. Each operator had to lift every article 18 in. on to his machine and lower it the same distance back to the trolley. New trolleys the same height as the machine soon reduced the amount of backache in that shop.

In another case, a pickling vat 6 in. deep was placed on the floor, and had been used in that position from time immemorial, parts being immersed by hand, spread out, and later collected by stooping women for carrying to the next operation. Bringing the vat to the level of the benches improved conditions considerably.

A similar case of unnecessary discomfort was discovered when studying a hardening operation on long steel blades. The worker had to pick up the blade with a pair of tongs in his right hand, raise the furnace door with his left, and insert the blade into a slot in a rack inside the red hot furnace. Before closing the door, he had to pick up a blade from the other end of the rack (where the blades were red hot) and remove it for quenching. It was found that operators regularly had several days off work through the third finger of the right hand becoming temporarily paralysed. An examination of the tongs revealed that they were the same type that blacksmiths have used since Tubal Cain forged the first sword. The addition of a spring between the handles removed the strain from the operators' fingers, and saved the firm many days of lost work.

When a new employee was started on this job, blisters soon appeared on the right hand, in spite of the asbestos gloves. This was found to be due to hesitation and fumbling while picking up the heated blade. The redness of the furnace, rack and blades made it very hard to distinguish separate blades. A spotlight was eventually fixed in such a position that it threw green light across the rack when the door was opened, causing deep black shadows to appear between the blades. This prevented any more blisters.

Many operations such as the above are taken for granted in hundreds of old-established businesses, but the remedies suggested are only the prelude to mechanisation. For instance, the trolleys in the first example would logically be replaced by continuous conveyors, the pickling operation would be included in an automatic dipping conveyor, and the hardening would be done in a continuous furnace.

machines are considered

Apart from badly-planned jobs of the foregoing types, there are always operations which need plenty of effort and cannot be avoided. Mechanical power is the only way to deal with these. If the operation can be achieved by a standard machine already on the market, the only problem is the choice of the right model, but if no such machine exists, then a special machine will have to be created. With regard to " standard " models, it is important to make sure that nothing superfluous is included in the specification. Some machines are supplied complete with tools and fittings to cover a multitude of jobs, and some also have numerous adjustable parts to widen the scope of the machine. When choosing a machine for a specific purpose, the production engineer should select the model with the smallest number of adjustments compatible with foreseeable requirements, and with only those tools and fittings suitable for the present objective.

Referring back to our hypothetical output of 5,000,000 articles per year, we need to reduce this to more practical units to find out the machine capacities required. Allowing 50 weeks for production, the target becomes 100,000 per 40 hour week, or 2,500 per hour. Again, allowing for reasonable stoppages, a rate of 3,000 per hour or 50 per minute would be expected from each machine or set of machines, and of course from the operators.

Simple tests will soon show whether it is feasible to expect an operator to work at a speed of 50 per minute, hour after hour, without fatigue. If 25 per minute is more reasonable, then two machines are required, or where capital expenditure and space are limited, a second shift may have to be worked on one process to keep up the overall output. If possible, a third machine, as a reserve, should be considered.

In one typical example, a firm interested in machines for drilling holes in special wooden articles, ordered an investigation into comparative costs and performances. Two alternatives were studied : firstly, a fully adjustable machine capable of drilling any one of 10 different shapes at 30 per minute; and, secondly, a set of simple machines each capable of drilling only one shape. Estimates showed an overwhelming collection of evidence in favour of the simpler machines. The comprehensive machine would have cost £2,000 to install, and it would have taken two hours to change over from one size to another, and therefore short runs on any one size would have been expensive.

On the other hand, the smaller machines cost only £250 each, change-over time was eliminated, and it would be possible to produce more than one shape at a time. The extra cost of purchasing and installing 10 small machines was outweighed by the safety margin acquired, and the flexibility of production, to say nothing of the cost of maintenance of a complicated machine compared with simple machines.

special machines

Where there is no existing machine suitable for a particular process and a special machine has to be produced, the designers will need to know everything about its intended function. It is very seldom sufficient to supply a sample component to the designers with instructions to make a machine to produce it or alter it. Even before the real analysis begins, the following questions will be asked :-

1. How is the machine to be fed? (manual, magazine, conveyor, etc.).
2. What is the maximum and minimum output allowed?
3. How consistent is the article entering the machine?
4. What tolerances are allowed in the outgoing article?
5. Which way up is the delivery required?
6. How is the operation performed at present?
7. What services are available on site (electric current, compressed air, etc.).
8. What are the limitations of available space?
9. What handling equipment is or will be involved?

These and other questions relating to specific industries must have their answers carefully weighed, but the machine designer must eventually learn at first hand all he can about the material and the process. The best kind of engineer to tackle the job is one who has a scientific mind and training, but no previous knowledge of the process. He will have nothing to unlearn. His mind will be open to receive any new impressions without having to struggle against the bias which a lifelong practice of routine creates. The first move of the designer is to observe the process being done by the old method, analysing each stage. He must be very critical of every movement, enquiring the reason for it, and its importance. After reducing the process to its basic elements, then a mechanical device has to be evolved to perform these motions, or at least to produce the same effect on the material.

In all special machines, it will be found that most troubles occur where the material or component is actually touched by the machine parts. These parts actually in contact with the subject are the real substitute for human fingers, and sometimes have to resemble them. If the machine is handling separate articles, as distinct from a flowing material, it is a sound maxim, once each article is gripped, to perform as many operations as possible before releasing it.

Three elements in machine design should be avoided wherever possible. The first is the use of friction to perform some definite task. The coefficient of friction between any two surfaces depends on so many variables that a frictional force is an unpredictable quantity, inconsistent and treacherous. The second element is the use of gravity to move articles from place to place. A freely rolling or sliding component can behave erratically. All members and components should be held, pushed, pulled, rotated, etc., by positive forces. Springs are, of course, necessary in almost every machine, but they usually act as resetting forces or shock absorbers. Springs should always be easily accessible for replacement.

The third dangerous element is excessive momentum. Wherever a machine member has to move intermittently or swiftly, such as an oscillating part or an indexing movement, that member should be as light as possible, and its acceleration and deceleration should be as smooth as possible. Violent movements will wreck the machine sooner or later, if it has not been designed to withstand the shock loads involved in stopping and starting heavy masses.

Before proceeding to design a complete machine, the basic components should be made up as simply as possible and manipulated so as to achieve the desired process experimentally. This apparatus, called a "mock-up", will expose any fundamental error in the method under test, but a full series of experiments must be made in order to confirm any theories. Unless identical results can be obtained time after time with identical conditions, the method is at fault. Carefully kept records of all preliminary tests are vital to the final design. It has been said that to produce a machine that is 100% efficient, the results on the "mock-up" should be 101% correct!

The experimental model can often be used to discover quantitative data, such as pressure required, heat generated, wear due to abrasion, and effect on the appearance of the material being handled. Some cases may warrant a rough working model

being made up and run for a considerable period under production conditions, before commencing the final design. If careful records are again kept, this period will be well worth while, as some defects appear only after hundreds of cycles of operation.

As special machines can take an infinite variety of forms, only brief general rules can be offered as a guide. The following will be found useful in most cases :-

1. Obtain as much of the machine as possible from stock or standard parts. This applies particularly to such units as electric motors, reduction gears, clutches, bearings, couplings, hydraulic, pneumatic and electrical components, universal joints, and so on. It is usually cheaper to design the machine to take the standard parts than to design special parts, and the replacement problems are reduced.
2. Arrange the machine as far as possible in sub-assemblies or small units, which can each be removed with the minimum of dismantling. This facilitates preventive maintenance and replacements.
3. Group the controls in a convenient position for the operator, especially the "STOP" button.
4. Make sure that failure of electric supply or compressed air supply, or any spring breakage does not set up dangerous conditions. In other words, make the machine "Fail to Safety".
5. Although the performance is more important than the appearance, a smooth outline with few dust-traps is desirable in the finished machine.

schemes and installations

When submitting a complete scheme for mechanisation of a factory, there will, of course, be included a list of standard machines and special machines, together with their respective capacities, floor space and current consumption. A scale model of the overall scheme is very valuable in planning the exact location of every piece of equipment, conveyors, internal transport and factory services. Along with the scheme must go a series of cost estimates proving the potential value of each unit. To check whether each machine or set of machines will pay its way, an analysis can be made thus :-

Make a list of the following items, giving them symbols as shown :-

I = Initial cost of new equipment (£).
K = Unamortised value of old equipment, less resale value (£).
X = Proportion of year during which equipment will be used (Decimal).

Fixed Charges: -
A = Percentage allowed for interest in investment (Decimal).
B = Percentage allowed for insurance, taxes, etc., (Decimal).
C = Percentage allowed for upkeep (Decimal).
$\frac{1}{H}$ = Percentage allowed for depreciation (Decimal).

Running Costs: -
E = Yearly estimate of cost of power, supplies and other consumables (£).

Credit Items: -
S = Yearly saving in direct labour (£).
Ta = Yearly saving in overheads on labour (£).
Tb = Yearly saving in fixed charges on old plant (£).
U = Yearly earnings through increased production (£).

This information can be obtained partly from existing records and partly from estimates supplied by manufacturers or research departments. The following questions can now be answered for the benefit of the accountants and directors.

1. What is the maximum investment that will give the required interest (A%)?

$$\text{Investment } Z = \left\{ \frac{(S+Ta+U-E)\,X+Tb}{A+BA+C+\frac{1}{H}} \right\} - K$$

In other words, the justified investment is obtained by dividing the annual net savings by the annual claims against them, and then subtracting any loss on the plant being replaced.

2. What is the annual cost of maintaining the new equipment ready for use?

$$\text{Cost } Y = I \left\{ A+B+C+\frac{1}{H} \right\}$$

3. What is the annual profit from using the new equipment?

$$\text{Profit } V = [\,(S+Ta+U-E)\,X+Tb\,] - [\,Y+(KA)\,]$$

or, net savings, less fixed charges and interest on lost capital.

4. How many years will it take for the equipment to pay for itself out of earnings?

$$H = \frac{I}{[\,(S+Ta+U-E)\,X+Tb\,] - I\,(A+B+C) - (KA)}$$

A simple example will indicate the use of these formulae.

Suppose that in a certain foundry six labourers are employed, using hand-trucks, to deliver castings to various parts of the machine shop. Their wages are 30s. per day. The trucks originally cost £60, but £30 of this is still not written off (K). Their

resale value is negligible, also their upkeep cost. The factory works 300 days per year. It is proposed to replace the six men at 30s. per day by installing an overhead monorail conveyor requiring one skilled man at £3 per day and one labourer at 30s. per day. The cost of installation (I) has been estimated at £1,200. The various symbols will now be:-

I = £1,200.
K = £30.
X = 0.8 (as the increased efficiency means the plant will be operated only 80% of the time).
A = say 6% (0.06)
B = say £48 (0.04).
C = £240 or 0.20 at 10% per annum depreciation, $\frac{1}{H}$ = 0.1.
E = say £120.
S = (300 × £9)-(300 × £4 10s.) = £1,350.
Ta = say 10% of £1,350 = £135.
Tb = Nil.
U = say £200.

By substituting in the formulae given above, it can be proved that the installation would still give satisfactory returns even if the cost had been £3,055 (Z), while the proposed plant at £1,200 would pay for itself in 1.4 years.

Not every proposition would yield such favourable results, and it will sometimes be necessary to examine two or more alternative methods in order to select the best one. The results of these calculations should be indicated when submitting the general scheme for approval.

When the complete plan for mechanisation has been submitted, discussed and finally approved in principle, the next step is to obtain the machines. Existing models will have been provisionally earmarked by the Planning Department, and will be ordered as required, taking into account the various delivery periods. More time will of course be needed for the supply of special machines. It may take 12 months or more to get into the production line all the machines specified, so the actual delivery and installation should be planned very carefully.

To avoid loss of current output, each new machine should be located so that its erection will not stop production, and so that the final changeover can be effected without undue delay. Sometimes it is necessary to move the old unit, complete with tools, workbenches, etc., to a temporary site while the new machine is installed. In other cases, it is possible to complete the erection of the new equipment in an adjacent building, where tests and adjustments can take place, before moving it into final position during a weekend or holiday period.

A complete shut-down of work is very seldom necessary or desirable, even though continuation might mean erratic production schedules for a time, due to the uneven capacities of different parts of the production system. In an old-established business, these conditions have their compensations, as the transition period gives more time for adjustment of habits of thought and routine. If tact and understanding is used in the planning of this period, it will be found that the actual completion of the change will hardly be noticed, whereas a sudden crash into high production could cause serious disturbances both inside and outside the organisation. The store-keepers, for instance, will need time to get used to the new large quantities, not to mention the new storage and handling equipment. The operatives in other parts of the factory also need a period of familiarisation with the conveyors, pallets or other new kinds of transport bringing them their work. By the time the increased turnover is in full swing, the elements of strangeness, mistrust and perhaps hostility will have had time to subside.

Outside the factory the suppliers of raw materials will have been notified of the coming increase in demand, and trial orders will be delivered, inspected, and stored against the day of full output. The consistency of raw materials, in quality, quantity and regularity of supply, is a very important factor in a smooth-running production line. At the other end of the organisation, the wholesalers, transport contractors, exporters, shipping companies—in short, all who are to handle the finished products of the factory, should be ready to receive the increased output and deal with it promptly. Otherwise, there will be chaos all down the line.

influence of colour

While on the subject of change, the question of colour deserves consideration. The old "battleship grey" that used to dominate all machine shops should become a thing of the past, along with the Victorian brown and cream throughout the offices and corridors. In the machine shops, an operator with a handsome-looking machine will take pride in keeping it clean and in perfect condition, while in the offices a brght outlook in all directions engenders optimism and self-confidence, which both tend to increased efficiency. In all departments, bright-coloured waste-bins help to keep things spick and span. At the Ford plant at Dagenham, all waste-bins were raised 12 in. off the floor to facilitate sweeping, and all dark and dirty corners were cleaned out and painted white. Another good hint is to mark all gangways with white or yellow lines, to indicate the area that must be kept clear of obstruction.

The change in the factory will be not only in outward appearance, but also in the spiritual atmosphere. With the burden of heavy labour removed, the production workers will be able to think of other things than knocking-off time and sneaking a "break". The end of the day will find them with enough energy left for recreation, and the prospect of this will shorten and brighten working hours. Each person should have his own or his team's target of output, and the resulting spirit of competition should also tend to improve atmosphere.

Mechanisation often enables a firm to reduce the number of hours in the working week, and this has many times proved to be a factor in increased productivity, due to the brighter feeling all round. One Managing Director indicated another reason for mechanisation. Pointing to a row of negroes doing a

particularly arduous job, he said. "This kind of work is beneath human dignity. I shall be pleased if I can get a machine to do it, even if it costs a little more that the present method".

Change will be apparent in the Production Planning Department, where a clear picture of all work in progress and on order will be kept constantly up to date, and any possible hold-up foreseen and forestalled. Maintenance of machinery will be preventive rather than corrective.

In the Board Room, a graph of steadily rising output will be balanced by a similar curve showing rising sales, while in between will be a graph of falling cost per unit.

Acknowledgments

Material and ideas have been obtained from the following books:-

"Great Engineers" by Prof. C. Matschoss

"Production Planning" by J. W. Hallock. (Ronald Press.)

"Principles of Mass and Flow Production" by F. G. Woollard. (Iliffe.)

"Production Control in the Small Factory"—British Standard No. 1100 Part 2. 1944.

"Interchangeable Manufacturing" by Earle Buckingham. (Industrial Press.)

Other books recommended for further study are:-

"Mechanical Movements" by T. W. Barber. (Spon.)

"Factory Administration in Practice" by W. J. Hiscox and J. R. Price. (Pitman.)

Besides the above there are, in the Public Libraries, books by experts on every conceivable trade or industry, wherein those interested can find information about the latest developments achieved by progressive firms.

MANAGEMENT EDUCATION AND TRAINING—*concluded from page 181*

exception of the primary work study course, which is held on a full-time basis in Copenhagen, these courses are arranged according to the nature of the demand. Some are run in provincial towns and in firms as well as in the capital, and may be full-time, part-time or evening courses. The D.I. is also prepared to organise within-plant training in any of the subjects covered by its regular courses and, as far as possible, tries to meet the particular needs of the firms concerned.

One should also mention that the Federation has organised a series of courses devised to cover the different subjects of the "Training Within Industry" scheme, and these courses are intended for all levels of management, from the foreman to the chief executive. In the teaching of all these courses the D.I. and the D.A.F. rely largely on their own staffs, but will use qualified instructors from business firms where appropriate.

supplementary activities

It would be wrong to leave this survey of the management education and training activities of these organisations without making clear what would doubtless be assumed, namely, that they are by no means the only bodies engaged in this work. Their activities are supplemented in many important ways by the work of universities, trade associations, professional groups, individual firms and others. However, in sum the work of the employers' organisations is probably the most important and this is partly a function of their prestige and influence and of the funds that they can command. They are often in a position to do valuable pioneer work if they choose, and to set examples that others can follow.

The Scandinavian employers' federations have not only been convinced of the need for management education and training, but have given their conviction practical expression. Each country takes an interest in the activities of the others and from what can be gathered it seems likely that their work in this field will be extended in the future. To give but two examples, Sweden is desirous of spreading a knowledge of work study still more widely and of broadening the scope of its application: Denmark has in mind the introduction of supervisor training courses, possibly akin to those at Skogshem.

Each country has its own different problems to solve, and in each it is important to consolidate the achievements of the past few years and to try to measure as accurately as possible the gains derived. It is not easy to calculate in any absolute sense the value of much management education work, particularly in the case of courses which are general rather than technical in character. This problem has received considerable attention in the U.S.A. recently, but categorical answers have not yet been found. For the time being a substantial amount of management education is undertaken for reasons of faith or fashion, and this is perhaps as true in Scandinavia as elsewhere.

But no one who studies the work of the employers' organisations there can fail to be impressed by the sincere belief of the people involved in the value of their work, nor of their desire to improve it wherever they can. Management education and training in these three countries has been developed with vigour since the War, and are plainly considered to be essential weapons in the struggle for greater industrial efficiency, better industrial relations and a higher general standard of life.

MANAGEMENT EDUCATION AND TRAINING IN SCANDINAVIA

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IN each of the three countries — Norway, Sweden and Denmark—there is both a Central Employers' Confederation and a Federation of Industries, corresponding broadly to the similarly named bodies in Britain. The Scandinavian Employers' Confederations, however, differ from their counterparts here in a number of ways and especially in the extent of their engagement in management education and training. They are committed, financially and otherwise, to provide or support courses which cover a wide range of subjects, designed to meet different managerial needs.

The Federations of Industries, with the exception of that in Denmark, are less directly active in this work, although in all cases they are interested in and sympathetic to it. Some of the courses now being offered are quite original in concept and design, while others have been influenced by the earlier experiences of Britain and the U.S.A. Even so, care has been taken to make sure that, as far as possible, the lessons of this experience have been absorbed in the light of each country's particular problems.

The educational activities of the employers' organisations may be of interest to people engaged in management training in Britain and this article gives a description of the work being done in Scandinavia, together with some comments on its general effectiveness.

Norway

In 1951, the Norwegian Employers' Confederation (N.A.F.) started to provide courses that were designed to help managers to get better results from works joint production committees. The courses were given over a period of two years and when they ended in 1953, the Confederation decided to extend the range of its educational work. It now offers a number of courses, organised and directed by members of its permanent staff.

1. There are two courses, known as "A" and "B", intended for both general managers and specialists. During the first of the courses the work of the Confederation and of the central trade union organisation is described; laws and regulations affecting the place of work are dealt with and there are discussions covering a variety of management-labour problems. Case studies are used and rôle-playing has been introduced.

   The "B" courses are restricted to people who have already attended the "A" courses and although much the same kinds of topics are taken up again, they are dealt with more intensively and the course members are also encouraged to talk about the wider, social responsibilities of employers.
2. Additional "A" courses are organised for single industries — road transport, for example.
3. Other courses combining the principal features of the "A" and "B" courses are given for personnel managers.
4. Finally, there have been several miscellaneous courses arranged for more restricted groups with special interests in a particular trade, or aspect of business operations, such as a course for journalists and a course on job evaluation.

These are all short courses and last for only two to four days. To serve those members who live in the Oslo region, or in parts accessible to it, the courses are held in a fine country house at Elingaard, about 40 miles from the capital. If sufficient demand exists the Confederation also arranges courses in more distant places, such as Trondheim, Narvik and elsewhere on the West coast. Details of these courses are published in the Confederation's fortnightly journal, "Arbeidsgiveren".

The N.A.F. is very interested in the main executive development programme in Norway, which is held at the Solstrand Hotel, Os, some 20 miles from Bergen. In 1952 a group of managers from 10 of Norway's largest concerns met to hear Professor Waaler, of the Norwegian School of Economics and Business Administration in Bergen, outline his plan for a combined programme of education and research in business administration, conceived to raise the level of managerial efficiency in the country. The scheme was approved, financial support was obtained and a new body, known as the Administrative Research Foundation (A.F.F.) was created. It is governed by a board on which the School of Economics and Business Administration, the N.A.F. and the Federation of Norwegian Industries are represented and it organises and conducts the Solstrand course.

In view of the difficulty of sparing executives from their firms for long periods, the decision to arrange a course lasting 12 weeks was a bold one, but so far the success of the scheme has justified it. Each year the members of this course (they numbered 42 in 1959) meet for two sessions of six weeks each, in spring and autumn, and their work programme has been devised with the following objects in mind.

It is intended to stimulate and develop powers of leadership in men who either hold senior managerial positions or who are considered to be probable candidates for promotion to such positions in the near future. The course is related as closely as possible to a manager's job as it is believed to be — for instance, it has been estimated that senior managers may spend as much as 15 to 20 hours a week in conference with other executives, so the course tries to increase the efficiency with which these meetings are run. Efforts are made to broaden the outlook of the men on the course by overcoming the narrowly specialist ideas that some of them hold and by encouraging co-operation between experts and non-experts. A good deal of emphasis is put on the improvement of communications, both spoken and written.

working in syndicates

The 1959 course members were divided into four syndicates, each with as much variety of membership as possible. The syndicate leaders were members of the staff of the A.F.F., many of whom are brought in for this work from industry and from consulting concerns on a short-term basis. These leaders prepare cases and problems for the syndicates to discuss and a major part of the syndicates' work is the production of succinct reports, in which all members take part. The syndicate meetings are followed by general meetings. These may take two forms — the syndicate chairmen (a position held by all in turn) can speak for their respective groups, or they may be asked to initiate a debate into which the other members are drawn as soon as possible.

Lectures are used only to a limited extent and are mainly reserved for providing background information where necessary. Case studies are important and as many as 40 may be used during the course. The cases are usually followed by rôle-playing sessions, when some of the members act their solutions of the cases, and afterwards there is a critical discussion of what has been seen and heard.

main fields covered

The main fields of study covered in this course are these: the individual company and its relations with society, the organisation structure and functions of the company, the economic and financial problems of the company, and its psychological problems. Within these broad subject groups, a large number of detailed topics receive attention and the members have some choice to allow them to follow special

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Since 1951, he has been Lecturer in Economics in the University of Hull, with special interests in the organisation of industry and business administration. He has visited and written about business schools in the United States, and in 1959 he made a study of management education and training activities in Scandinavia and the Netherlands, under the auspices of the European Productivity Agency.

interests. Generally, one can say, all the most important current problems of business organisation and operation will be considered during the course.

After giving this course for several years the opinions of those who are responsible are these. The place of meeting is satisfactory: it is isolated and this encourages concentration and closer acquaintance, and makes for frequent, informal discussions outside formal class meetings. The work of the syndicates has been carefully watched and it is believed that this method of training, by virtue of the close contacts which it promotes, can decidedly make for greater freedom of expression and criticism, while at the same time it promotes strong feelings of loyalty and a spirit of mutual helpfulness. Much of the success of any syndicate, however, depends upon a careful choice of its members, so as to secure the optimum balance of age, background, interest and temperament. An open mind is still kept about whether or not the composition of the syndicates should be changed during the course, but the practice at present is to leave the groups unchanged during the Spring Session and watch how members adjust themselves, and then to make any changes which seem absolutely necessary before the Autumn Session begins.

importance of variety

The informality of the syndicates is balanced by the greater formality of the general meetings, which give practice in concise speaking and clear and constructive argument before a larger audience. The members of the course seem to approve the variety of teaching methods used and variety does appear to reduce the danger of monotony and increase the readiness to participate.

This course has been meant to serve less as a means for the dissemination of knowledge, than as a device for encouraging people to use more fully and effectively the knowledge they have already accumulated. They are given the opportunity to do things and find out things for themselves, rather than led to think that things will be done for them, because it is held that the lessons they learn then will be more lasting.

Managers have come to these courses from a variety of firms and from Government departments and non-commercial organisations as well. In view of the length of the course and of its cost — about £300 — there is an admitted problem for the smaller firms, which are likely to find it more difficult than the large ones to spare their senior men for three months of a year. Furthermore, Norway is a country with a small population and a correspondingly restricted industrial sector: it does not have many large firms, or even medium-sized firms, which can be relied upon to provide a steady flow of executives to these courses.

The course for 1959 was just comfortably filled, but without any fierce competition for the available places. In coming years the number of applicants may well diminish. The sponsors of this interesting, and in many ways adventurous, course have not yet said how it might be reorganised if demand for it were to fall to such an extent that it could not be continued in its present form. To shorten it at all drastically would be to destroy many of its advantages, and to attempt to cover the present curriculum in a shorter period would lead to excessive strain on participants and staff, with a concomitant sacrifice of the quality of the work done. It remains to be seen, therefore, what changes will be made if present conditions alter. That they may eventually do so is a real possibility.

Sweden

The Swedish Employers' Confederation (S.A.F.) started its management education work soon after the end of the last World War, so that it has a rather longer record in this respect than the N.A.F. Schools were started by the Confederation in 1946 to instruct the employers about the work of the Enterprise Councils (joint works production committees) and its efforts were parallelled by similar activities on the part of the trade union movement and the salaried employees' association. From this limited beginning grew the idea of undertaking management education on a more ambitious scale. The S.A.F. felt that it was in a good position to do this work, because it was better able to provide centralised facilities than any single industry or firm. It also believed strongly that the employers should look after their own needs and not delegate responsibility for management education to some outside concern.

In 1948, the Confederation bought a country mansion at Yxtaholm to serve as a centre for its educational work and courses were first held there in 1950. Then, in 1952, the top management courses began, lasting initially for four weeks, but later being extended to five with a subsequent one-week meeting to provide a "refresher". Two advanced management courses are now held in each year.

The Yxtaholm course, which usually has 32 members, is designed to present company problems from the standpoint of the chief executive to people whose careers have been of an essentially specialised kind. These are typically men with an average age of 40, and 15 or more years of company service, who are likely candidates for early promotion to positions of general management. The course they attend is divided into four main sections covering the following groups of subjects:

(a) business policy, organisation and leadership (5 days);

(b) personnel administration and collective bargaining (6 days);

(c) business and society (3 days);

(d) business economics (5 days).

At the end of the course there is an integration seminar which was not included in the earlier courses. It lasts for five days, during which the work of the preceding month is summed up and coordinated. Other changes that have taken place are

the reduction of time devoted to personnel problems and an increased emphasis on economic matters.

The members of the course work in groups of six to eight and, as part of their work, each is required to imagine himself as the newly appointed chief executive in a simulated business situation and to make plans for his company in the year, two years and five years following his "appointment". Instruction is given by informal lectures and discussion groups, case studies are used and there is a limited amount of rôle-playing. In terms of the time devoted to study, case work is the most important of the methods, since many hours must be spent outside the classroom in reading up the cases and preparing background material. An interesting feature of this course is that the case study groups are not supervised by the teaching staff. It has been found that cases obtained from other countries are often not suited to the needs of Swedish managers and the S.A.F. has been building up its own library of purely Swedish cases.

emphasis on general aspects

The teachers have also learned that techniques have to be introduced into a course of this kind very carefully. This has been especially true of that part of the course concerned with personnel management, in which many members have shown too much readiness to seize on certain systems or methods of personnel administration and treat them as panaceas. Considerable care is now taken to illustrate the general aspects of personnel problems, rather than to describe particular techniques. While the usefulness of various tools of personnel management is discussed, the dangers that can accompany their careless use are firmly stressed. The same caution is being exercised in the introduction of business games, for again there is a danger that the game may become an absorbing end in itself.

The S.A.F. draws its teachers from the universities, business firms and the consulting profession, as well as from its own staff. Applications for admission to the course are accepted only from companies and members are enrolled strictly in order of the receipt of their nominations. This unusual system has been adopted because it is considered fairest to all concerned and, although the S.A.F. has apparently relinquished its powers of selection, one is told that in practice the balance of age, experience and ability of the course members has been satisfactory.

The Confederation has its own staff of work study experts, trained to teach the subject, and they are to be found in most of the main industrial centres. Work study courses are arranged on an area basis and conducted by the local S.A.F. teacher, usually in an industrial plant. These courses, of which the average membership is 30, are spread over a number of months and involve in all about 270 hours of study time. At the request of the national trade union organisation, the S.A.F. has also instituted work study appreciation courses for trade unionists, lasting for three weeks.

course for supervisors

The third way in which the Swedish Employers' Confederation engages in management training is in the organisation of a course for supervisors. As long ago as 1930 an Institute for Training Supervisors (A.L.I.) was formed by the Federation of Swedish Industries and it began operations in 1931. The S.A.F. joined the Federation in 1949 and they exercised a joint responsibility for the work of the A.L.I. until 1956, when it was agreed that the S.A.F. should take over on its own. Partly as a testimony to its belief in the importance of supervisor training, the S.A.F. decided to build a magnificent permanent centre for the supervisors' course at Skogshem (Lidingö), near Stockholm.

Here one should mention the work of another body set up in 1952, the Swedish Council for Personnel Administration (P.A.R.), which receives annual grants from the S.A.F. and which is governed by a board having some of its members appointed by the S.A.F. As part of its activities the P.A.R. has encouraged the creation of a Chair of Social Psychology and Personnel Administration in the Stockholm School of Economics, and has also taken over the supervisor selection work formerly done by the A.L.I. This work consists of research into methods of improving supervisor selection and training, and the provision of a consulting service to industry, which is also intended, wherever possible, to lead to the gathering of useful research material.

The supervisors' course at Skogshem is seen as but one part, although a very necessary one, of a long-term programme of supervisor development, both within and outside the company. The Institute's course lasts for three to four weeks and at any time there are three courses running. The emphasis is on increasing the supervisors' knowledge and understanding of human relations and industrial psychology, but about one-third of the time is devoted to the economic and organisational aspects of their work and to factory legislation, safety and hygiene.

demand for specialist courses

So far these courses have drawn members from a wide range of industries and it has been the policy of the organisers to have this mixture, since they felt that many of the problems faced by supervisors are common to all kinds of work. But there has been increasing pressure from individual industries and firms to have courses arranged specially for them and the S.A.F. now finds it virtually impossible to resist these demands. In the future, therefore, it is probable that more single industry courses will be held and that, to make good some of the loss of the advantages of "cross-fertilisation" which the present courses offer, shorter conferences for supervisors from several industries together will be arranged.

The length of the supervisors' course was decided upon as the minimum that would give the members time to adapt themselves to their new surroundings

and work and enable them to cover the necessary basic studies that it was thought essential to include. The S.A.F. has been well aware, however, that many firms might find it difficult to spare supervisors for as long as a month, and to cater to their needs local courses have been started which are spread over a period of about three months. During this time supervisors can meet perhaps twice a week, in the afternoon or evening, for a few hours, and so cover the greater part of the work which they would have done had they gone to Skogshem.

Denmark

The Danish Employers' Confederation (D.A.F.) began courses for senior managers in 1955, shortly after it had acquired for this purpose a former royal estate at Egelund. The reasons for the Confederation's venture into management education have been stated by its Director of Studies, Herr Arne Lund, in a Paper dealing with the work of the Egelund school.

He says that it was thought that the material progress and welfare of the workers could be increased considerably if employers and workers were to co-operate more closely in their daily relations in industry. But for this to happen the employers had to make the first approach. An improvement in " the *community relations* between the employers as a social group and the rest of society " was also considered to be as important as an improvement in industrial relations. As a result, Danish employers had tried "to get out of their isolation" and improve both industrial and social relations. They wanted " to play their part in the creation of a progressive economy and a prosperous democracy ". In the light of these statements it is not surprising to learn that the educational activities of the D.A.F. are closely related to the work of its Public Relations Department.

At the present time four different types of courses and conferences are held at Egelund. The first is a course for branch officials of trade associations and officers from the local divisions of the D.A.F. This course provides information about the more important current aspects of the labour market — changes in wage rates, the level of employment, conditions of work, social legislation, and so on. The second course is designed for individual employers and senior executives and is primarily concerned with problems of personnel administration and human relations in business firms.

contact meetings

In order to promote a better understanding of each other's work and aims, *contact meetings* are arranged periodically to enable groups of employers (national or regional in composition) to meet groups of trade unionists, politicians, journalists, educationists and others who may be affected by, or in their turn affect, the policies and working conditions of business enterprises.

executive development programmes

Lastly, there is an executive development programme, which started in 1957, consisting of two four-week sessions, run in collaboration with the Federation of Danish Industries. This course is intended to provide a forum where modern managerial methods and relations between firms can be discussed. There appears to have been an assumption that this course would attract men mainly from the larger industries, since the D.A.F. has also organised shorter courses for the small industries in conjunction with the Federation of Danish Handicraft.

The Federation of Danish Industries (D.I.) is noteworthy in that it, too, has provided a number of training courses since 1946. The Training Department formed in that year set out to adapt to the peace-time needs of Danish industry the lessons learned in industry elsewhere during the War, especially in industrial engineering and human relations. Throughout the post-War period these courses have been subject to adaptation and expansion to keep them of most use to their members. Since the courses are essentially technical in character they complement rather than compete with those of the D.A.F.

The D.I. offers a number of work study courses :

1. A *primary course* to train work study practitioners and to show the most effective ways of introducing work study to a firm. Each course lasts for six weeks, divided into two equal parts.
2. A *briefing course* of shorter duration (50 - 60 hours) during which people with a knowledge of work study are helped to employ their techniques in the optimum manner.
3. A course in *ratio delay* (lasting about 40 hours) is for imparting a theoretical knowledge of this subject and also for giving some practical demonstrations of its value.
4. There is a course in *synthetic and functional time standards* (80 hours).
5. Lastly, a *materials handling* course (40 hours), designed to give a better understanding of analysis technique and methods of transport rationalisation.

The membership of all these courses is usually subject to an upper limit of 15.

Other courses offered by the Federation deal with industrial organisation and production control, cost accounting and budgeting, and quality control. Membership of these is again limited to 15 to 20 and their duration varies from 50 to 70 hours. With the

(*concluded on page* 176)

TRAINING PRODUCTION ENGINEERS FOR THE JOBBING INDUSTRIES

by E. G. BARBER

Company Education Officer,
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TRADITION has it that the old-time Production Manager in the jobbing industries was a bowler-hatted gentleman with a frightening personality, tremendous experience, a fierce pride in his lack of schooling, and a capacity for making weighty decisions on the spur of the moment and ruthlessly applying them without fear or favour.

Certainly most were men who, through competence, initiative and personality, had risen from the ranks of manual workers. It was under these men that the great jobbing industries, heavy engineering, ship-building and so on, made tremendous progress in the latter part of the last century and the first half of this one.

Before attempting to decide how to train their successors, it is first necessary to consider why these men have done so well.

The jobbing industries have some special characteristics which make the problems of production management very different to those in the process and mass production industries. Most of the work of the jobbing factory is done in small batches, whether it is the assembly of the complete product or the making of the separate detail parts. There are no highly organised assembly lines and few repetitive tasks. There is little automatic equipment.

Operators are repeatedly moving on to new work. Many of them are skilled. Premises, equipment and services are all chosen and arranged for their adaptability to many jobs. There is great variety of raw materials, of components, of bought-out fittings and of techniques and processes. There is often no possibility of preliminary development work with prototypes. Manufacture for the customer has to be straight from the drawings. Changes are frequent during manufacture — changes at the customer's request, or improvements, the need for which shows up as work proceeds, or substitutions brought about by late delivery of bought-out materials and fittings. Many jobbing products are large and complex, taking many months, perhaps years, to design and manufacture — time enough for many unforeseeable problems to arise.

Jobbing production is then complicated, variable and unpredictable. Accurate forward planning and orderly prearranged progress are piously hoped for, but rarely achieved. Urgent short term production problems are legion.

For all these reasons, the production engineer who mainly concerns himself with long-term planning and programme controls often has a frustrating time and is not infrequently discredited by events. The one great quality which can save him is the ability, as the odds seem to build up against him, so to deploy his staff and facilities that he overcomes all the problems and obstacles and still gets the job out on time and at the right price. This ability to organise large scale improvisation calls for toughness, strength of personality and a lively mind, but above all it requires a very thorough and detailed knowledge of equipment, techniques and practices, organisation and people throughout the whole field concerned with getting his job done.

It is not surprising that so many production

engineers in the jobbing industries have begun on the shop floor and have been upgraded through shop supervision or through planning, progress or jig and tool design, because of their thorough experience as well as their intelligence and personal qualities. Through the years it is largely these sorts of men who have controlled the building of our ships and aircraft, our power station equipment and bridges and cranes and other specialised general engineering products, and their success is not in question. Why is any new approach now needed?

social and educational changes

First, social and educational changes are such that very few young people of the potential of the older production engineers are now finding their way into trade apprenticeship and so into the ranks of shop floor workers. There is very efficient creaming off at 11-plus into Grammar Schools, at 13-plus into both Grammar and Technical Schools, and at 15-plus into further full-time courses. More are regraded out of trade apprenticeship into student apprenticship during industrial training. The youth with very good potential is most unlikely to be overlooked at all these stages and to continue as a rank and file worker on the shop floor.

Meanwhile, the products of jobbing industry are becoming more and more complicated and sophisticated, and so are the means of making them and the materials used. New methods of organising and controlling production are evolving, sometimes calling for quite advanced mathematical knowledge. Generally production engineering is becoming an exacting technology and calls for the same scientific approach as design and development work. What is more, changes are coming increasingly rapidly, so that to succeed the young production engineer must be able to keep abreast of rapid technical development and contribute to it. Experience alone is becoming less and less adequate.

The Universities and Technical Colleges are providing short courses to assist practising production engineers to keep in touch with new developments. So are a number of private training establishments, and many large employers are arranging courses themselves. A steady flow of technical literature is also available. By these means many are keeping abreast of new developments in their own fields. But the basic training of the next generation of production engineers must equip them from the beginning to work in these new and changing conditions, and to contribute to further rapid development during their own careers.

The future jobbing production engineer needs the same courage, initiative and ability to improvise, based on sound experience, that his predecessor had, but now he has to add a technological training of the same order as the designer or development engineer. The gap has to be bridged between the hard-headed up-from-the-ranks practical man and the trained theoretical engineer of graduate standard, and we have to find a way of training a man with the abilities of both.

A senior jobbing production engineer in the future will therefore probably have been an intelligent, well-educated boy, who was selected for the right personal qualities and trained and further educated to the limit of his capacity academically, as well as by practical experience, in preparation for his career. These notes suggest how his education and training might be planned with these ends in view.

First, the young man's school education should stimulate in him adaptability, fertility of thought, initiative and the capacity to go on learning. It should include a sound foundation in mathematics, physics and chemistry on which to build up his further technical education and in English so that he may learn to communicate well. It should include practice in craftsmanship so that he may experience the pride of a practical job well done, and this comes, not from operating expensive and complicated machine tools at school, but from shaping wood or metal with hand tools at the bench. He should read literature, look at art, hear music and study history and geography so that he can better understand and enjoy the world around him and learn to live a full broad life outside his work. He will probably stay at school until he is 18 and take and pass his "A" level G.E.C. in Mathematics, Physics and Chemistry and be a prefect.

Mr. Barber studied for an Engineering Degree and subsequently for a Diploma in Education at Bristol University from 1930 - 34, and did post-graduate training with Standard Telephones & Cables Limited, North Woolwich.

He lectured at Woolwich and Northampton Polytechnics in Mechanical and Aeronautical Engineering and subsequently spent a number of years in industry in South Africa, first as a Design Engineer, and later as Production Manager.

He returned to England in 1953, and shortly afterwards took up his present appointment.

When he leaves school he will be selected to train as a production engineer, because of an independent flexible mind, a strong but pleasant personality, plenty of initiative and drive and a liking for working with others, as well as because of success in his studies.

On leaving school and before carrying on to any further full-time study, he should next experience industrial life in the type of industry in which he hopes to make his career, so that he gets a picture of the aims, methods, products and problems of the industry. This must come at this stage if he is to have a full sense of direction and realism in his technical studies. He will, in fact, use his further studies to help him interpret and generalise from his industrial experience.

He should obtain his first experience of industrial life by joining a "student" or "engineer" apprenticeship scheme in which his training will be properly planned.

practical training

This will begin with practical training in the basic techniques of engineering. He will do a variety of benchwork and learn to use a range of machines, so that he gains confidence and can play a useful part in the departments of the factory he works in later. Then he will follow a planned programme of work in a series of shops, becoming thoroughly familiar with all aspects of the work and organisation of those shops. Whilst doing this he must develop an interest in, and understanding of, those amongst whom he works, so that he learns to work well with them and get the best out of them.

In this workshop training he will benefit from a good deal of direction. In a well-planned training scheme he will probably attend lectures, discussions and films on workshop practice, on the organisation of the factory and functions of the departments and on the products of the Company. His training should not be merely by the time-honoured method of standing watching others. He should be given as much as possible to do for himself. He should be required to collect information and report fully in writing on what he learns. He will gain very greatly from the opportunity of discussing these reports regularly with experienced production engineers and with his fellow apprentices.

day release studies

Meanwhile, he will probably begin studying at a Technical College in a National Certificate Course in Production Engineering, to which his employers will release him on one day a week. During the first year or two, whilst he is doing this, his employers will be assessing his promise as a production engineer and if this is high and his O.N.C. record is good, he should be selected to take up a Sandwich course of study leading to a Diploma in Technology in Production Engineering. He would attend this full-time for six months of each year for four years, continuing with his industrial training for the other half of each year.

His Diploma course should provide further basic education in Mathematics, Physics, Chemistry and English, together with specialised classes in Workshop Technology, (not techniques, which he will learn better at the factory), jig and tool design and metrology. It should also include the principles of production planning and control, elementary cost accounting, data processing and work study. He should be introduced to economics, statistics and industrial physiology and psychology. The course should be designed to make him think methodically. He must be trained in scientific method, learning how to make measurements and to collect factual information, how to assess the information collected and use it to arrive at reasoned objective conclusions as a basis for action. The course should include projects designed to encourage him to work independently and if they can be linked with his works experience as well as his studies, so much the better.

Meanwhile his industrial training will go on. As a production engineer in this type of industry he has to build up a wealth of detailed knowledge of all the complexities of production in his own type of jobbing concern. The longer he can spend in working around the shops gaining practical experience, the better he will be equipped for leadership in production work later, but this practical experience should continue to be carefully planned and guided. It should be detailed and wide. It must extend him. He should have to write critical and constructive reports, if possible on real live problems, and have someone with whom he can discuss them.

living as one of the group

Generally, his training should not include long periods spent on work of one kind, but very great value would come from one single period of, say, six months to a year spent working in a single department under precisely the same conditions as the men around him. During this period he should join in incentive schemes, read the same newspapers, join the Union (if they will have him) and in every possible way he should live as one of the group. He should always be studying his fellows and learning all he can about them.

All the time, he should be relating principles and practice — at the works he must look for examples of application of the principles, at College he must seek to interpret what he sees at the works. There should be a good and close relation between his factory and his College, on a basis of equal partnership. College and factory staff should meet and discuss training together on the shop floor and in the production offices, in the College laboratories and workshops.

Intelligent young men with a little industrial experience and a Diploma in Production Engineering are very much sought after nowadays, particularly in the mass production and process industries where much of the theoretical content of Diploma courses can be applied immediately and long industrial experience is of less importance. And here lies a dilemma for the jobbing industries. They would like the young man to go on accumulating practical

experience, to go on finding out more and more about machines and men and methods. They are not even sure he is the man they want until he has really got himself steeped in practical "know how", and has shown over several years that he can improvise with his feet as firmly on the ground as the next man. He begins to wonder whether he will ever find his way up and become a key man in the industry, and he is tempted to leave and do something like work study or operational research in one of the mass production industries. He loses faith in his employers. His employers sometimes feel that he is expecting too much with inadequate experience and lose faith in him. They are even heard complaining that "what we need is some of the good old-style skilled men who know the factory inside out and will stay with us and train up . . ." But of course these are few and far between nowadays.

This dilemma can only be dealt with by recognising it, explaining it to the would-be production engineer and then deliberately setting about guiding and encouraging him, making him feel he is wanted and seeing that he is not unduly out of pocket whilst he is building up his experience and establishing a reputation. It this is done, the really promising young man will often understand what is wanted and be prepared to continue his training on the shop floor beyond the end of his apprenticeship.

three main sub-divisions

By the time he has secured his diploma and done a worthwhile basic training, he will recognise several sub-divisions of production engineering and should know in which sub-division he wants to specialise during his early career. Broadly, in a large organisation he will find three main sub-divisions, namely :-

(a) technical work such as design of jigs and equipment, development of new techniques, method study and some parts of planning;

(b) administrative work where he might be concerned, for example, with organisation and systems, programme planning and programme and stock control;

(c) work where he would be involved in direct supervision of production on the shop floor.

Each of these calls for a different further development plan after the end of apprenticeship. The young engineer is not now simply in training; he also has to justify the salary he receives. He should now set about building up both his experience and his on-the-job reputation by spending much longer periods, of say a year or two, in each of several departments mainly relating to one of these three divisions of work.

Beyond the end of studies for the Diploma in Technology there are further possibilities of improving one's academic knowledge in production engineering. The College of Aeronautics at Cranfield provides a very successful two-year course in production engineering of post-graduate standard. This is intended for youths with a first qualification such as a diploma or degree, and some industrial experience. The College has also established an outstanding reputation with its 10-week intensive course in work study. Though the College is generally associated with aeronautics, these particular courses are mainly concerned with general principles and so are applicable to production engineering in the widest sense. The College has already trained some first-rate young men, far too many of whom have been lost to the aircraft and jobbing industries because they are so much sought after by the mass producing and process industries.

PERA's contribution

The Production Engineering Research Association is making a useful contribution in accepting young engineers who have completed their basic studies, and training them for six months in a full-time course in which they work with the PERA research teams.

These are only two of the several possibilities for post-graduate study in production engineering. In considering them, the young production engineer must weigh the value of further study against more practical experience. He must appreciate that his progress will rest not on more certificates, but on the rate at which he can prove himself on the job. Further studies should be chosen only if he can see in them a means of equipping himself better for the career that he should by now be picturing in some detail. In the jobbing industries, the indications will often be in favour of experience rather than more study.

a plan for the majority

These notes outline a modern plan for the training of the jobbing production engineer. This is not the only way. There will always be outstanding men who will reach their positions by unconventional means. The University graduate with his trained mind may compensate for lack of formal production training by private study and hard work in the factory. Outstanding "late developers" from the shop floor will make their way up by hard private study and conscientious work. But the broad path for the majority will be something like the one described here.

The large jobbing employer, recognising the rapid and fundamental changes in both industry and education, must be ready to re-think this whole problem of sources of his future production engineers. He must be ready to recruit suitable people and give them planned training of the kind described. Only so will he find enough men of the right sort to maintain Britain's place in world production as successfully as their bowler-hatted predecessors.

The views expressed by the author in this article are not necessarily those of his Company.

Production Engineering Research Association of Great Britain

Quarterly Newsletter to the Institution

Management Economics Department

IN the original PERA research plan published at the time of the formation of the Association, provision was made for a division of the activities to be concerned with the field of Management Economics.

During the past three years increasing demands for the Association's services in this field have been matched by an expansion of facilities, and this development has necessitated the creation of a separate department. Mr. P. K. Digby, A.M.I.Prod.E. has been appointed Manager of the new Department of Management Economics.

The scope of the new department extends to all management functions, and subjects dealt with include organisational problems, administrative systems, paper work simplification, management controls, job evaluation, etc. Many measurable benefits have resulted from the implementation of PERA's recommendations, and in addition to the direct economic benefits, many intangible benefits have accrued, particularly in relieving stress on higher management. Assignments are conducted on a completely confidential basis for fees.

Direct Industrial Training Courses

The Five-Day Direct Industrial Training Courses are to be continued during 1960. The programme for each of the existing courses has been modified to enable recent developments and up-to-the-minute techniques to be included.

Practical demonstrations in the Education and Training Department workshop now include: Ceramic Tools, Hydraulic Copying, Square-cycle Milling, Sub-press Units, etc. Details of PERA's Education and Training programme for 1960 are given in the Newsletter

A General Appreciation Course, which is suitable for all types of engineering personnel from managers to chargehands, covers a wide range of subjects in the fields of machining, forming, press work and machine tools.

The courses specialising in particular fields of engineering production have been revised. Metal Cutting Course "A" will in future be known as the "Practical Machining and Metal Cutting Course", and as the title implies, more time will be devoted to practical demonstrations. This has been made possible by the acquisition of additional machinery for demonstration purposes. A course on "Modern Machining Techniques", which replaces the former Metal Cutting Course "B", is of particular value to executive engineering staff.

Increasing attention is being given to the whole field of presswork and metal forming generally, and the course on these subjects is therefore being repeated. The programme provides more time for discussions of modern tooling techniques for both large and small batch production, and demonstrations will include the manufacture of jigs, tools, etc., from plastics and similar materials.

A number of One-Day Conferences of particular interest to Directors and Works Executives will also be held during the year. During these Conferences, various aspects of PERA's most recent work on production techniques and equipment will be described and demonstrated.

research

The current metal cutting research programme includes a study of the performance of ceramic cutting tools, an investigation of boring and trepanning techniques, and the determination of the machining properties of a range of commonly used steels. Work being carried out on reaming has yielded new information which is expected to be of considerable benefit to industry.

Research into the cold extrusion of steel is being extended to meet the increasing demand for reliable data on this subject. Attention is also being given to other metal forming techniques such as deep drawing and thread rolling, and the life of blanking and piercing punches manufactured from various types of tool material is being evaluated.

Some tests with explosive forming have confirmed that this technique has considerable potential where small quantities of components of complicated shape are required.

In addition to the comprehensive study of work handling techniques which has been carried out, attention is now being directed to the construction of a special machine tool feed drive simulator which will greatly facilitate the testing and further development of numerical control equipment. Other aspects of the extensive programme of machine tool research include the performance of cylindrical grinding machines, fundamental studies of machine tool slideways in connection with the development of hydrostatic slideways, and investigations into the vibration characteristics of machine tool structures.

AUTOMATIC CONTROL CONGRESS, MOSCOW

Application forms for those wishing to attend the first I.F.A.C. Automatic Control Congress in Moscow, which is scheduled to take place from 27th June - 6th July, 1960, are available from Mr. W. Bamford, Hon. Secretary, The British Group for Computation and Automatic Control (Group B), c/o The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

It is hoped that if a sufficient number of people attend, it will be possible to arrange for travel to and from Moscow and hotel accommodation there, over the period of the Congress, at reduced rates.

ERGONOMICS RESEARCH SOCIETY ANNUAL CONFERENCE

The Annual Conference of the Ergonomics Research Society is to be held at the University of Cambridge, from 28th - 31st March, 1960. The closing date for applications is 21st March.

Forms of application, together with details of the programme, may be obtained from Dr. S. Griew, University of Bristol, Department of Psychology, 22 Berkeley Square, Bristol, 8. (Telephone 24161, Ext. 231.)

PROGRESSING INDUSTRY EXHIBITION

The Kingston Area Productivity Association is holding an Exhibition from 21st - 23rd April, with the following aims :

1. to enable manufacturers and traders of the Kingston area to demonstrate their products and to stimulate sales.
2. to show how they have learned to apply their improvements in method, and have advanced in knowledge and technique, so as to provide the public with a better service.
3. to show young people what opportunities there are for them in industry and commerce and the area, and what they need to study in order to grasp these opportunities.

Further particulars may be obtained from the Exhibition Sub-Committee, Kingston Technical College, Fassett Road, Kingston-upon-Thames, Surrey.

A VISIT TO INDIA

reported by F. W. COOPER, M.I.Mech.E., M.I.Prod.E.

Education and Technical Officer

Institution of Production Engineers.

SIR Walter Puckey was recently invited by the Ministry of Scientific Research and Cultural Affairs of India to attend the 47th Indian Science Congress at Bombay, on 3rd - 7th January, 1960, and later to deliver lectures and to participate in seminars and symposia at Universities and Colleges. Accompanied by the writer, three centres, namely Bombay, Calcutta and New Delhi, were visited and the opportunity taken to see something of the industrial, educational and social life of India.

At the inauguration of the Science Congress we had the honour to be presented to Prime Minister Nehru and later attended a wide variety of lectures such as "Atoms and Human Knowledge" by Prof. Niels Bohr; "Science and Industry" by Sir Ewart Smith; and "Elementary Particles" (far from elementary) by Prof. Abdus Salam. We reciprocated by giving talks to the Psychology and Education Group, Sir Walter also addressing Work Study students at the Productivity Centre and myself the Institution of Locomotive Engineers.

Visits to the Victoria Jubilee Institute and the Indian Institute of Technology, Powai, were valuable, particularly the latter where the U.S.S.R. has provided the equipment and the greater part of the professorial staff.

A very fine example of the well laid out works, with ultimate provision for housing all employees and with schools and market, was seen at Godrej Ltd., manufacturers of refrigerators, metal furniture, etc.

Thanks are due to the members of the Bombay Section of The Institution of Production Engineers, whom we had the pleasure of meeting, and to Mr. Miller in particular, for their kind hospitality.

Sir Walter Puckey and Mr. F. W. Cooper with members of the Bombay Section Committee. From the left (seated): Mr. C. R. Pal, Vice-Chairman; Sir Walter Puckey; Mr. Alec Miller, Chairman; Mr. P. V. Shah; and Mr. Cooper. From the left (standing): Mr. R. A. P. Misra; Mr. R. D. Mistry, Hon. Secretary; Mr. J. V. Patel; Mr. R. N. Rai; Mr. W. P. Karnik, Hon. Treasurer; Mr. G. L. Lewis.

After two weeks in Bombay we proceeded to Calcutta which, although continually bathed in sunshine, had not the same temperature or humidity. The Calcutta Section had arranged a most interesting programme which included visits to four works, including Jay Engineering Ltd., and Guest, Keen and Williams; the Universities of Jadavpur and Calcutta, and the Indian Institute of Social Welfare and Business Management. Two most inspiring Colleges were also visited, the Ramakrishna Mission and the Calcutta Technical School.

We both addressed the Engineering Students at the Universities and Sir Walter was most busy with talks to the Institute of Social Welfare and Business Management, to a Joint Meeting of the Institution of Production Engineers, and the Institute of Engineers (India) and to the Management Association. We had the pleasure of meeting the Calcutta Section where the main topic was again the proposed Council of India. Our thanks are again due to many good friends and in particular Mr. Goodchild, Mr. O'Leary and Mr. Sen Gupta, Principal of the Calcutta Technical School, and their good ladies, for many kindnesses. We were delighted to visit a village adopted by the Rotary Club of Calcutta.

The week in Calcutta passed very quickly and we then flew to New Delhi for the last few days of the tour. The contrast from the noisy and packed streets of Bombay and Calcutta was most pronounced, and even the trees managed to have an English look about them. The weather was much cooler with quite nippy evenings and mornings, and conditioned us for the anticipated chills of London.

Visits were paid to the Indian Management Association, to the Central Water and Power Commission and to the World Fair, where we were surprised to find that the United Kingdom was not represented. It was good to meet an old friend in Mr. H. E. Dance of the Ministry of Education, now putting in some fine work for the new College of Technology for which the British Government is finding £250,000 for staff and British industry £150,000 for equipment. Prof. Thacker, who as Secretary to the Ministry of Scientific Research and Cultural Affairs, was our host throughout the tour, made us doubly welcome in Delhi and to him and Mrs. Thacker go our grateful thanks.

Prime Minister Nehru receives Mr. F. W. Cooper, at the inauguration of the 47th Indian Science Congress, at Bombay.

It is hoped that further space will be found in the Journal for a full report giving conclusions reached as a result of the many contacts mentioned above with industrialists and educationlists. At the moment, it can be said that we believe the main obstacle to the very necessary rapid expansion required of Indian industry will be a shortage of adequately trained engineers and managers capable of running the new factories. For University graduates it was felt that a new bias towards these ends was necessary, and the general lack of practical training was deplored. Immediate consideration must also be given to an extension of part-time day-release Diploma courses; to the possibility of Sandwich courses for a higher award, and to the provision of more courses for Production Engineering and Management.

BINDERS FOR "THE PRODUCTION ENGINEER"

As a result of requests from members, the Institution is now able to supply the "Easibind" type of binder, in which metal rods and wires hold the issues in place, and which is designed to hold six issues.

It will be found that copies of "The Production Engineer" can be quickly and simply inserted into this binder, without damage to the pages, and that binding six issues at a time, instead of twelve, will facilitate easier reference and handling of the volumes.

The new binders may be obtained from: The Publications Department, 10 Chesterfield Street, Mayfair, London, W.1, price 10/6 each, including postage. Date transfers, for application to the spine of the binder, can be supplied if required, price 6d. each.

news of members

Mr. A. I. Baker, C.B.E., J.P., Member, Chairman of the Baker Perkins Group of Companies, has been appointed President of The British Engineers' Association.

Mr. L. R. Beesly, Member, has been appointed Superintendent of the Royal Small Arms Factory, Enfield, Middlesex.

Mr. A. R. Cason, Member, has taken up an appointment as Manager of a new factory in Greece manufacturing domestic and commercial refrigerators under licence for Kelvinator Limited.

Mr. A. Fraser, Member, has been appointed Assistant Works Manager of Linotype and Machinery Limited, Altrincham. Mr. Fraser, who is a Past Chairman of the Manchester Section of the Institution, was previously Superintendent of Machine Shops and Tool Room.

Mr. H. C. Knott, Member, present Chairman of the Manchester Section, has recently been appointed to the Board of his firm, Yates Duxbury & Sons Limited, Bury. Mr. Knott, who is General Manager of the parent company, already holds directorships of some of the subsidiary companies.

Mr. H. T. Jones, Member, formerly Works Director, has recently been appointed to the Main Board of Landmaster Ltd., a member of the Firth Cleveland Group. Mr. Jones has served as Executive Director for some years.

Mr. C. W. McDonald, Member, has recently taken up an appointment as Production Manager at Messrs. Villiers Engineering Co. Limited, Wolverhampton.

Mr. T. Penny, Member, has retired from Joseph Watson & Sons Limited, Leeds.

Mr. F. A. E. Pritchard, Member, has been appointed a special director, and to the office of General Manager of Vickers-Armstrongs (Engineers) Limited, Weymouth.

Mr. G. Ronald Pryor, President of the Institution, has been elected a Guardian of the Standard of Wrought Plate within Sheffield.

Mr. A. E. Reddell, O.B.E., Member, has been appointed a Director, and to the office of Director-in-Charge of the Weymouth works of Vickers-Armstrongs (Engineers) Limited.

Mr. B. E. Stokes, Member, formerly Production Engineer, Production Division, Letchworth Group, I.C.T. Ltd., has now joined Borg and Beck Company Ltd., Leamington Spa. Mr. Stokes, who is Chairman of the Editorial Committee, also serves on the Finance and General Purposes Committee, the Education Committee, the Awards Sub-Committee, the Practical Training Sub-Committee, the Sub-Committee on Computers and Production Control, and the Conference Organising Committee.

Mr. W. Thompson, Member, has been appointed Joint General Manager of Peter Brotherhood Ltd., Peterborough.

Mr. K. Bird, Associate Member, has recently taken up a new appointment as Sales Development Engineer with Amalgamated Engineering Co. Ltd., of Lagos, Nigeria.

Mr. H. Bond, Associate Member, has recently been promoted to the position of Production Engineer for the Midland Electric Manufacturing Company Ltd.

Mr. H. G. Bottomley, Associate Member, General Manager of Landis Lund Limited, since 1st February, 1959, has now been appointed to the Board of Directors. Mr. Bottomley was previously Chief Engineer with Douglas Fraser & Sons Ltd., Arbroath.

Mr. G. Finglas Browne, Associate Member, has recently received the Insignia Award in Technology of the City and Guilds of London Institute.

Mr. C. Cameron, Associate Member, has relinquished his position with Lever Brothers (Port Sunlight) Limited, and has taken up an appointment as Senior Work Study Engineer of Standard Telephones & Cables Ltd., London.

Mr. S. W. Carroll, Associate Member, has taken up an appointment as Chief Engineer with Messrs. J. A. Wilson Lighting & Display Limited.

Mr. D. Coates, Associate Member, is now a Leading Draughtsman in the A.M.D. Division of The Plessey Company Ltd., Ilford.

Mr. G. C. Derbyshire, Associate Member, has been appointed to the Board of Directors of Frank Guylee and Son Ltd., as Works and Technical Director and also to the Board of The Jacobs Manufacturing Co. Ltd.

Mr. P. K. Digby, Associate Member, previously a member of the Director's personal staff at the Production Engineering Research Association, has been appointed Manager of the new department of Management Economics of the Association.

Mr. E. S. Dunthorne, Associate Member, has been appointed General Manager of the Telegraph Construction & Maintenance Co. Ltd., Metals Division, Crawley. Mr. Dunthorne is remaining on the Board of Directors of Telcon-Magnetic Cores Ltd., a subsidiary company of the Telcon Metals Division.

Mr. A. Edwards, Associate Member, formerly Superintendent of Engineering Services and Development at Linotype and Machinery Ltd., Altrincham, has been appointed Chief of Research and Engineering.

Mr. J. E. A. Heale, Associate Member, has taken up an appointment as General Works Manager, with Associated Electrical Industries (Woolwich) Ltd.

Mr. R. W. Hillyer, Associate Member, has relinquished his appointment as Works Manager at High Precision Equipment Ltd., to take up the position of Works Manager of Dyson & Co. Enfield (1919) Ltd., Bletchley Works, Bucks.

Captain R. L. Griffiths, R.E.M.E., Associate Member, has taken up a new appointment at the War Office Army Apprentices School at Carlisle, where he is Officer Instructor in Charge of the Armament and Instrument Sections.

Mr. A. J. C. Johnston, Associate Member, has taken up an appointment as Industrial Engineer with Messrs. Armstrong Cork Co. Ltd., Gateshead-on-Tyne.

Mr. A. E. Kirton, Associate Member, has relinquished his position as Works Manager, Railways Department, Port Louis, to take up an appointment as Personal Assistant to the Chief Mechanical Engineer, Nigerian Railway Corporation.

Mr. R. G. Lawrie, Associate Member, has been promoted from Chief Engineer of the Watch Division to Chief Industrial Engineer over the Clock and Watch Divisions, of Westclox Ltd.

Mr. H. J. Moon, Associate Member, is now a Liaison Engineer with The Plessey Company, Ilford. (Aircraft and Mechanical Division.)

Mr. F. C. Munns, Associate Member, has recently been promoted to Engineer I and has taken up an appointment as the Principal Inspector of Carriages in the Weapons Division of the Inspectorate of Armaments, Woolwich.

Mr. T. Newton, Associate Member, formerly with Edward Pryor & Son Ltd., at Sheffield, is now their Technical Representative in the London area. Mr. Newton was Hon. Secretary of the Sheffield Section before coming to London.

Major B. E. Peart, Associate Member, was recently appointed Works Manager of G. Sparshoot Ltd., Southampton.

Mr. J. J. Peck, Associate Member, formerly with Simms Motor Units Ltd., is now Works Manager of Charles Colston Ltd., London. Mr. Peck serves on the Research Committee of the Institution, and also on the Editorial Committee.

Mr. W. H. Rummey, Associate Member, has recently left England to take up an appointment with the British Automotive Industries Pty. Ltd., Sydney, New South Wales, Australia.

Mr. M. J. Sargeaunt, Associate Member, has relinquished the Editorship of Machinery Lloyd in order to operate as a Consultant. Apart from normal work in the field of production engineering, Mr. Sargeaunt has set up a Technical Writing Section for the preparation of Papers, handbooks, films, articles, etc., for those firms unable to deal with such matters within their own organisations. Mr. Sargeaunt serves on the Institution's Editorial and Library Committees.

Mr. R. Slater, Associate Member, Works Manager at Whessoe Limited, Darlington, is one of eight new Darlington Magistrates recently appointed by the Lord Chancellor. Mr. Slater is Vice-Chairman of the Tees-side Section of the Institution.

Mr. W. H. Sutton, Associate Member, has taken up a new appointment as Lecturer in Workshop Technology at Corlett Park Central College of Further Education, Eastham, Cheshire.

Mr. P. F. Thorpe, Associate Member, has relinquished his position as Works Manager with Winget Ltd., and has taken up the appointment of Works Manager with Woodfield Rochester Ltd., Rochester, Kent.

Mr. P. Warburton, Associate Member, has recently taken up the position of Assistant Chief Production Engineer within the Rolls-Royce Company, Derby. Mr. Warburton is Honorary Secretary of the Derby Section.

Mr. B. Bancroft, Graduate, has taken up an appointment as a Work Study Engineer (Trainee) with Mullards Magnetic Components, Southport.

Mr. E. W. Batchelor, Graduate, has been transferred from the Kaiser Aluminium & Chemical Corporation, Ravenswood Works, W. Va., to the Kaiser Aluminium & Chemical Corporation, Mead Works, Spokane, Washington, as a Senior Mechanical Engineer.

Mr. A. D. Cross, Graduate, has relinquished his position with Bristol Aircraft Ltd., as Personal Assistant to the Chief Estimator, to take up an appointment with Urwick Orr and Partners Ltd., as a Resident Consultant.

Mr. M. Gledhill, Graduate, has relinquished his appointment with Messrs. Rendel, Palmer & Tritton, and has taken up a position as Mechanical Engineer with Constructors John Brown Limited, London.

Mr. L. A. Hoefkens, Graduate, has recently been promoted from Quality Control Engineer to Quality Manager for Hardy Spicer Limited, Birmingham.

Mr. K. B. Karanth, Graduate, has now joined Messrs. India Pistons (Private) Ltd., Madras 11, as Assistant Engineer.

Mr. T. R. Knowles, Graduate, is now with the Stafford College of Technology as Lecturer in the Mechanical and Production Engineering Department.

Mr. A. Matthews, Graduate, is now Assistant Lecturer, Grade B, at the Rotherham College of Technology.

Mr. F. W. Mooney, Graduate, has been appointed Work Study Officer, Divisional Engineers Dept., I.C.I. Limited, Runcorn, Cheshire.

Mr. M. R. Pengelly, Graduate, has recently relinquished his position with Bristol Aircraft Limited, and has taken up an appointment as Development :ngineer for the Stoneywood Paper Mill of the Wiggins Teape Group.

Mr. H. P. Singh, Graduate, has recently taken up an appointment with the Triplex Safety Glass Fundamental Research Laboratory, Balsall Common, Warwickshire.

Mr. J. Michael Smith, Graduate, has taken up a new position as a Senior Foreman with English Electric Aviation Ltd., Stevenage.

Mr. W. K. Smith, Graduate, has taken up an appointment as a Work Study Engineer with Standard Telephones and Cables Ltd., Paignton.

OBITUARY

The Institution records with deep regret the death in January last of **Colonel C. G. Warren-Boulton,** Member, of the Calcutta Section.

Colonel Warren-Boulton, who was Managing Director and Owner of Machine Tools (India) Ltd., made a notable contribution to the establishment and progress of the Institution in India, and his work in this direction will always be remembered. Born in London, he was educated and served his engineering apprenticeship in Birmingham. After a short period with The Brooke Tool Manufacturing Company, Birmingham, as a draughtsman, he joined Alfred Herbert, Limited, and after spending two years in the Company's London Office went out to India, where he became Managing Director of Alfred Herbert (India) Ltd.

In 1924, he joined Thos. Robinson & Sons (India) Ltd., as Managing Director, and in 1928, he founded his own Company, Machine Tools (India) Ltd., with showrooms in Calcutta and Bombay, and representatives in Karachi, Lahore, Delhi and Bangalore.

Colonel Warren-Boulton joined the Institution of Production Engineers in 1939, and was also a member of the Institution of Mechanical Engineers, a member of the Institution of Engineers (India), and a member of the Council of the Institution of Engineers (India). He was at one time Honorary A.D.C. to His Excellency the Viceroy of India, and Colonel of the Calcutta and Presidency Battalion, A.F.I.

DIARY FOR 1960

MARCH 17 ... ... **The 1959 Viscount Nuffield Paper,** at the Rankine Hall, Institute of Engineers and Shipbuilders in Scotland, Glasgow.

Speaker: **Dr. C. Timms,** M.I.Prod.E., National Engineering Laboratory.

Subject: **"Recent Developments in Spur and Helical Gears"**

APRIL 23 ... ... **North Midlands Regional Conference, Derby**

Theme: **"The Production Engineer in a Changing Economy"**

MAY 11 ... ... **Sixth Conference of Engineers Responsible for Standards**, at the Connaught Rooms, London.

JUNE 27 ... ... **Summer Meeting,** at the Festival Hall, London, preceded by **The 1960 Viscount Nuffield Paper,** at The Royal Institution, London (see Journal Supplement).

AUGUST 24-28 ... ... **Symposium,** at The College of Aeronautics, Cranfield.

Subject: **"Machine Tool Control Systems"**

OCTOBER 19-22 ... ... **National Conference,** at Brighton.

Theme: **"Modern Trends in the Manipulation of Metals"**

NOVEMBER 2 ... ... **Annual Dinner,** at the Dorchester Hotel, London.

Hazleton Memorial Library

ADDITIONS

Members are reminded of the following Library rule, which is frequently ignored:

"The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

British Council, London. **"Annual Report, 1958 - 1959."** *London, the Council,* 1959. 114 *pages. Illustrated.* 1s.

British Standards Institution, London. **"The Operation of a Company Standards Department."** *London, the Institution,* 1959. 18 *pages.* 3s.

This report is sponsored by the Joint Standing Committee of The Institution of Production Engineers and the British Standards Institution. Contents: Introduction (basic principles and advantages of standardisation) — Functions of a company standards department — The fields of standards and variety reduction — Preparation of standards — Making standards effective — Classified coding (of standards) — The publication of standards. Appendix I: Note on the Lemon Report on standardisation of engineering products, and the Cunliffe Report on the British Standards Institution. Appendix II: Layout and headings of a typical company standard. Bibliography.

British Steel Castings Research Association, Sheffield. **"British and Foreign Specifications for Steel Castings."**

Part I — Summaries, comparisons and other relevant information. *Sheffield, the Association,* 1959. 48 *pages. Diagrams. Tables.* 40s.

Contents: List of specifications for steel castings for Great Britain, U.S.A., and certain European countries (Austria, Belgium, Czechoslovakia, France, Germany (Eastern), Germany (Western), Great Britain, Holland, Italy, Sweden, Switzerland, U.S.A.) — List of grade designations from specifications referred to in this book which are often used without reference to the parent specification number — Summaries of specified requirements (Austria, Belgium, France, Germany (Eastern), Germany (Western), Great Britain, Sweden, Switzerland, U.S.A.) — Appendix (Summary of test piece dimensions).

Butzco, Robert L. "**Plastic Sheet Forming.**" *New York, Reinhold Publishing Corporation; London Chapman and Hall,* 1958. 181 *pages. Illustrated. Diagrams. Tables.* 36s. (Reinhold's Plastics Applications Series.)

Surveys the applications and techniques of plastic sheet forming. Contents: Introduction — Applications of sheet forming — The fabrication techniques — Selecting the proper materials — Moulds and mould design — Commercial machinery — Auxiliary equipment — Decorating — Production costs — Prospects for the future.

Currie, R. M. "**Work Study.**" *Pitman for the British Institute of Management,* 1959. 232 *pages. Diagrams. Charts.* 22s. 6d.

The author is head of I.C.I.'s Central Work Study Department. His book is, in effect, a revision and expansion of the British Institute of Management's three pamphlets in the "Outline of Work Study" Series. The first three chapters place work study in its historical, industrial and sociological contexts. The rest of the book is essentially practical, giving descriptions of work study techniques accompanied by numerous charts and by illustrative examples.

Contents:- Historical: The pioneers — Productivity and work study — The human context of work study — Method Study: introduction — Method Study: examine — Method Study: develop and submit — Method Study: install and maintain — Work Measurement: introduction — Time Study: principles and procedure — Relaxation and contingency allowances — Synthesis from elemental data — Analytical estimating — Activity sampling — Target times for jobs — Unoccupied time (UT) and various allowances — Confirming work content and standard times — The work specification — Work study as a service to management.

"**Directory of Opportunities for Qualified Men.**" *London, Cornmarket Press,* 1960. 128 *pages. Charts.* 8s. 6d.

The 1960 edition of this Directory follows the same pattern as former editions. It should be useful to newly qualified men and women, and (particularly the section on executive courses) to employers and personnel managers.

Contents: After qualification what ? — The demand for executives; graphs illustrating trends shown by the Index of Executive Employment compiled by Management Selection Ltd. — Opportunities abroad; a factual survey prepared by the Economist Intelligence Unit — Qualified women; a survey of employment prospects — Executive courses, 1960; a list of short full-time courses for qualified men and executives. *Reference Section*: A wide selection of entries from companies and other organisations recruiting qualified men and women, in which they describe themselves, their work, and the opportunities they offer — Classified index listing companies and other organisations under headings which they have selected to describe their activities and giving other information in tabulated form for quick reference — Map showing locations referred to in the classified index with a list of counties in each area.

Duffin, D. J., and Nerzing, Charles. "**Laminated Plastics, including High-pressure and Low-pressure Types and Reinforced Plastics.**" *New York, Reinhold; London, Chapman and Hall,* 1958. 254 *pages. Illustrated. Diagrams. Tables.* 46s. (Reinhold's Plastics Application Series.)

The production, fabrication and application of laminated plastics, with numerous tables of physical, mechanical, chemical and electrical properties. Contents: Introduction — Chemistry and properties of resins — Basic materials and reinforcements — Manufacturing processes — Grades and characteristics of high-pressure laminates — Machining and moulding of laminated plastics and moulded parts — Heat resistant and other special laminates — Applications and end-products. Appendix A: A brief history of vulcanised fibre and phenolic laminate manufacturing. Appendix B: List of manufacturers of high-pressure laminates. Appendix C: U.S. trade names current in the laminated plastics industry. Glossary of basic laminated plastic terms.

Electrical Development Association, London. "**Process Integration and Instrumentation.**" *London, the Association,* 1959. 204 *pages. Illustrated. Diagrams.* (Electricity and Productivity Series, No. 8.)

"The object of this book is . . . to outline in simple form, the means by which the variables occurring in manufacturing can be sensed, measured, and controlled with the ultimate object of achieving a more completely and perfectly integrated process . . ." It describes in a coherent way the principles of the systems and machines which are used, and their practical applications. Sixty-three examples of devices for automatic measurement and control are given in the "industrial applications" section, e.g. level control by photocell; guiding of oxygen flame cutter; welder control; automatic batch weighing and proportioning. Amongst developments briefly discussed are mechanised store keeping; automatic handling; and automatic assembly. Most of the diagrams and photographs are of commercially available equipment.

Contents: Modern manufacturing — Automatic control — Sensing — Instruments and instrumentation — Electrical and electronic links — Actuators and servo-motors — Industrial applications — Computers — Control of machine tools — Movement of materials — Quality control — Design and servicing — Progress towards automation.

Floyd, Don E. "**Polyamide Resins.**" *New York, Reinhold Publishing Corporation; London, Chapman and Hall,* 1958. 230 *pages. Illustrated. Diagrams. Tables.* 36s. (Reinhold's Plastics Application Series.)

The methods of manufacture, basic chemistry and the practical application of polyamide resins are the subject of this work. Practical applications dealt with include fibres and filaments, coatings and films, mouldings, extrusions, adhesives, inks, castings and sealants. Developments of new resins and their uses are also considered.

Contents: Introduction — General properties of the polyamide resins — Basic chemistry of the polyamides — Manufacturing processes for polyamide resins — Coatings and films — Polyamide fibres — Moulding, casting and extrusion — Adhesives — Water dispersions, Organosols, inks — Future trends in polyamide resins.

Gould, David F. "**Phenolic Resins.**" *New York, Reinhold Publishing Corporation; London, Chapman and Hall,* 1959. 213 *pages. Illustrated. Diagrams.* 46s. (Reinhold's Plastics Application Series.)

The first chapter surveys the present use of phenolic compared with that of other plastics; successive chapters deal with chemistry and properties, resin production and application. Contents: Present status of phenolic resins — Raw materials — Resin production — Moulding compounds — Adhesives — Laminates — Wood production — Bonding and impregnating agents — Coatings — Castings, foams and spheres — Rubber compounding — Applications not otherwise classified — Prospects.

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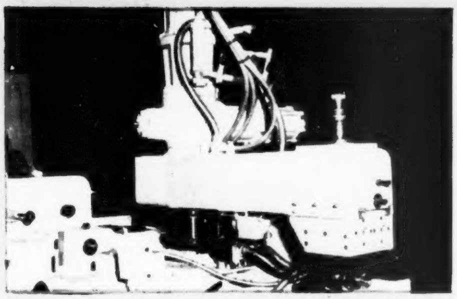

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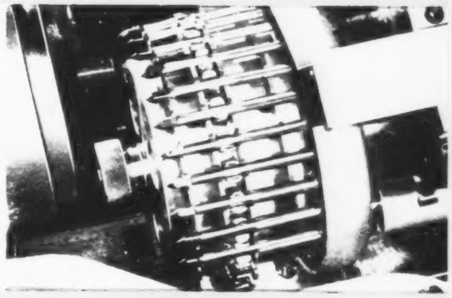

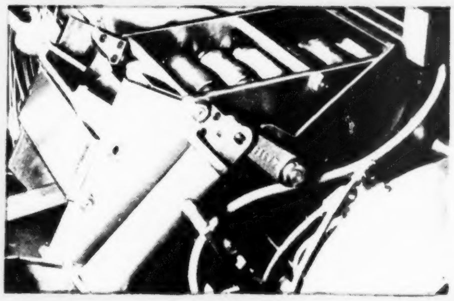

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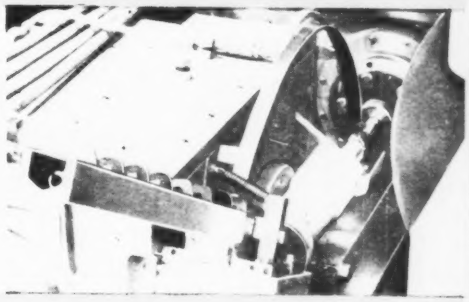

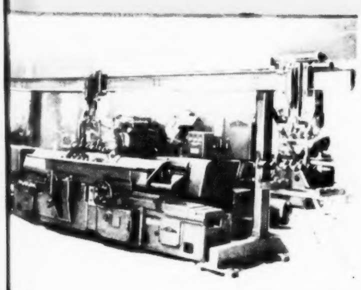

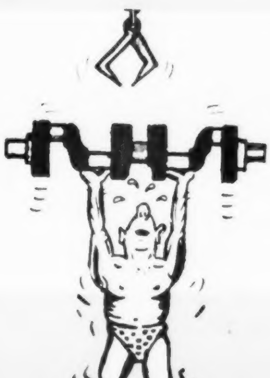

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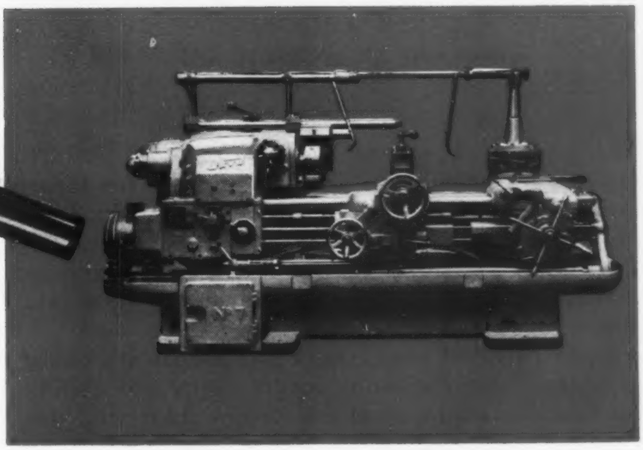

Photograph by courtesy of H. W. Ward & Co. Ltd., shows Enots Coolant fittings on a No. 7 'Prelector' Combination Turret Lathe.

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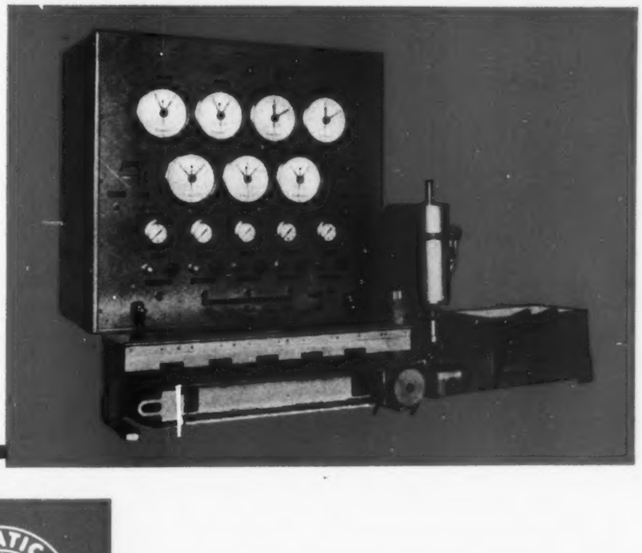

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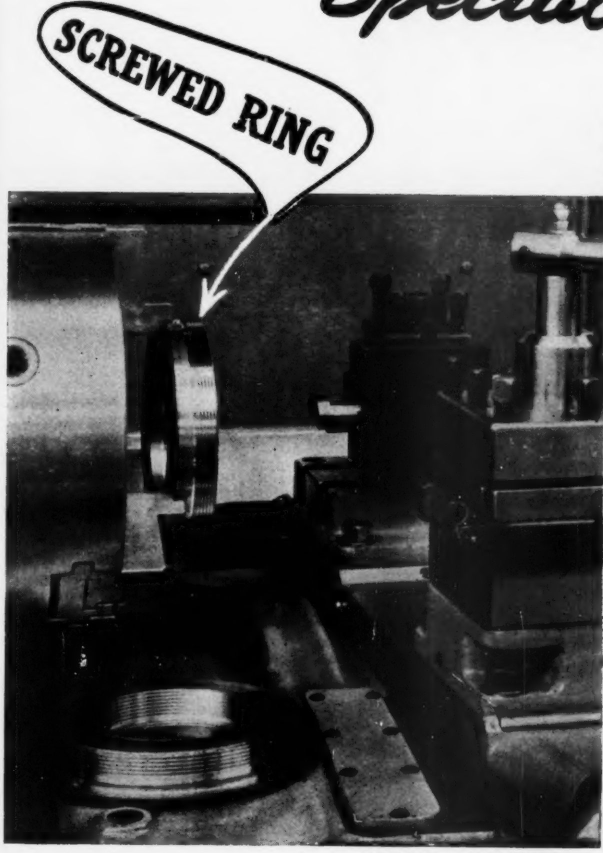

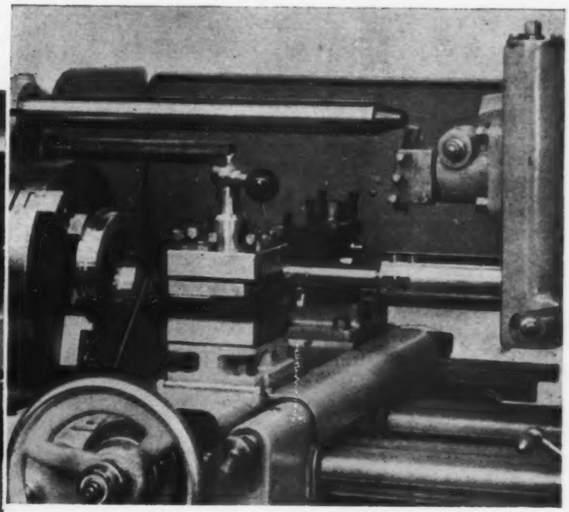

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No. 7 TURRET LATHE

FITTED WITH 12in TUDOR 3-JAW CHUCK

STEEL FORGING

40 Ton Tensile Steel
En.8.

All Tungsten Carbide Cutting Tools

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Grip Forging in Three-Jaw Chuck	—	—			
2. Turn Outside Diameter	—	Front 1	416	765	266
3. Undercut and Face Flange and Chamfer o/dia.	—	Front 2	416	765	Hand
4. Screwcut o/dia. × 11 T.P.I. (7 cuts)	—	Front 3	280	495	11 T.P.I.
5. Face End	—	Front 1	675	1193	52
6. Bore, Undercut and Chamfer	1	—	416	408	134
7. Screwcut Internal Thread 11 T.P.I. (7-cuts)	—	Rear	416	408	11 T.P.I.
8. Remove Part from Chuck	—	—			

Total Floor-to-Floor Time for above operations: 5 minutes.

NOTE:— Time for cutting external thread 11 T.P.I. (7 cuts) *40 seconds*
Time for cutting internal thread 11 T.P.I. (7 cuts) *36 seconds*

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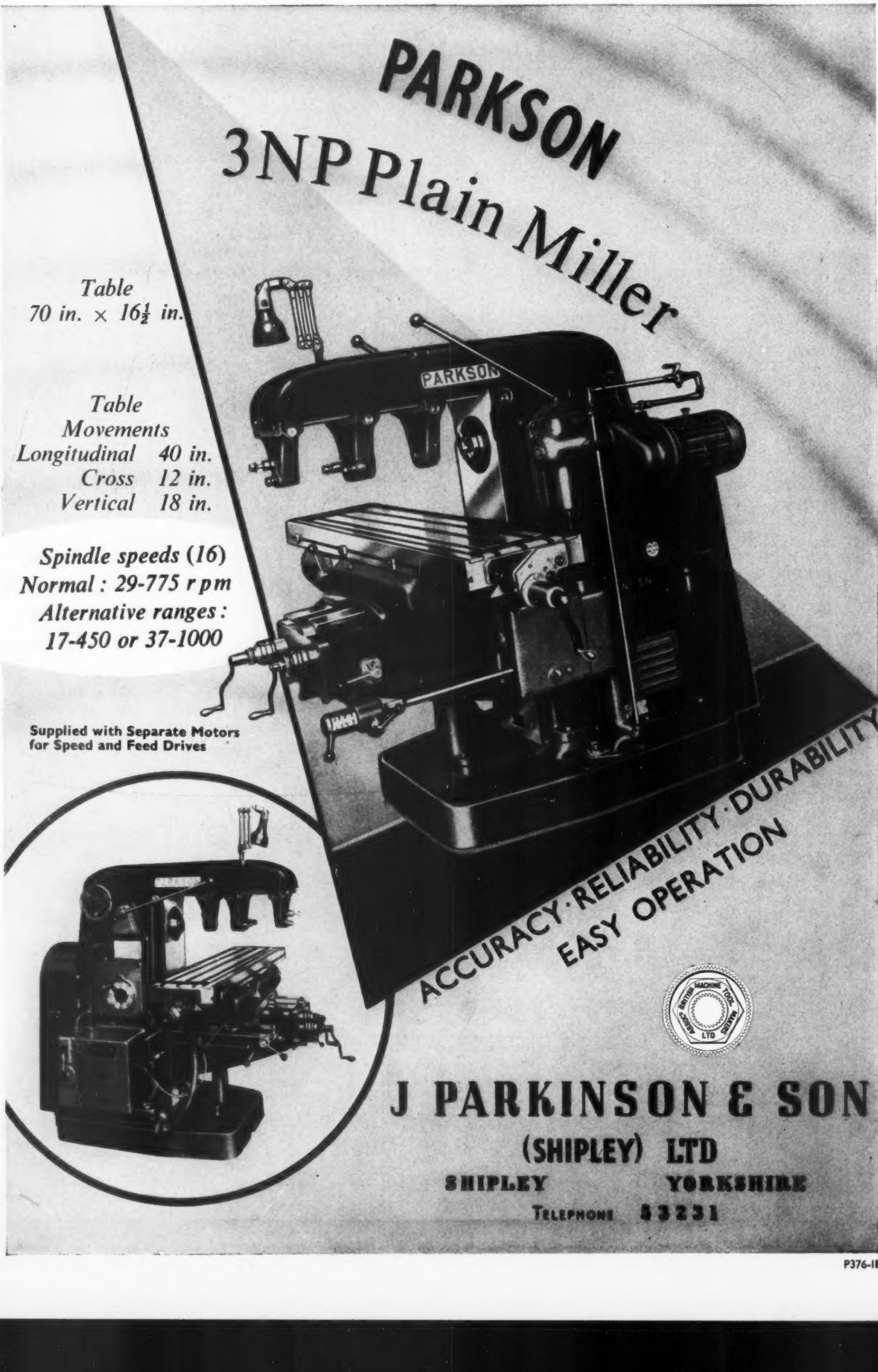
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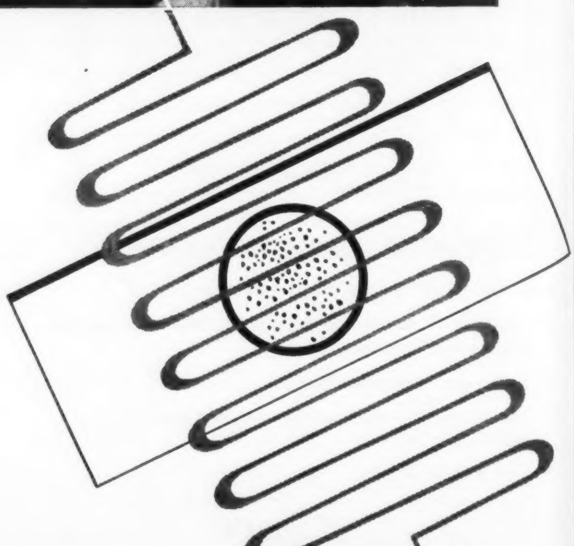

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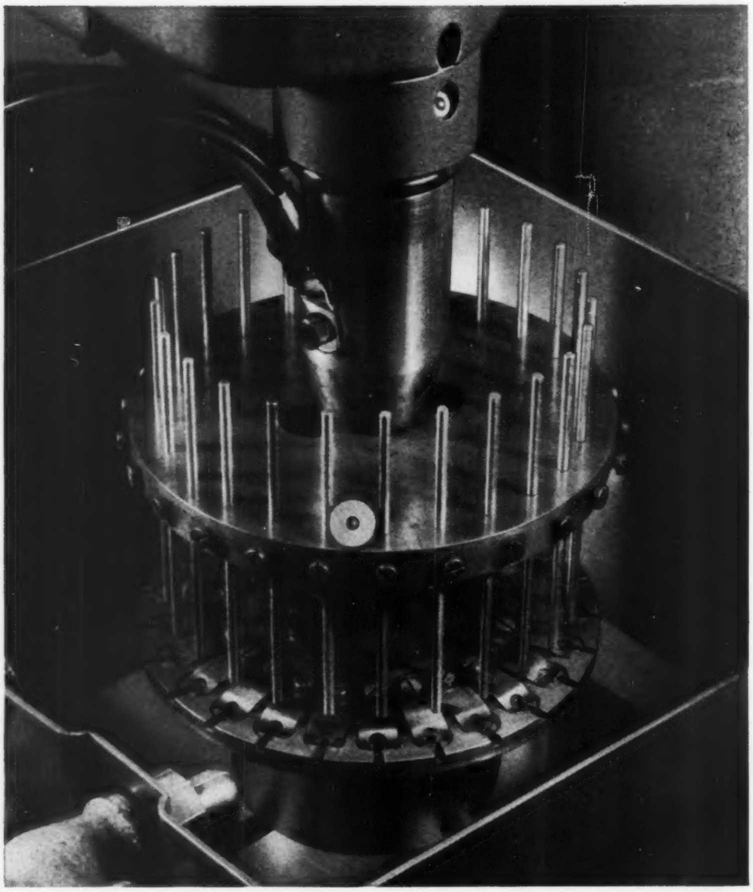
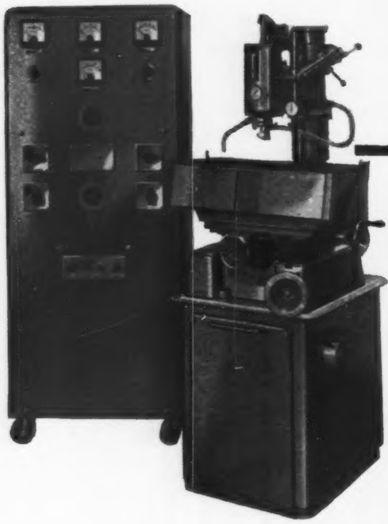
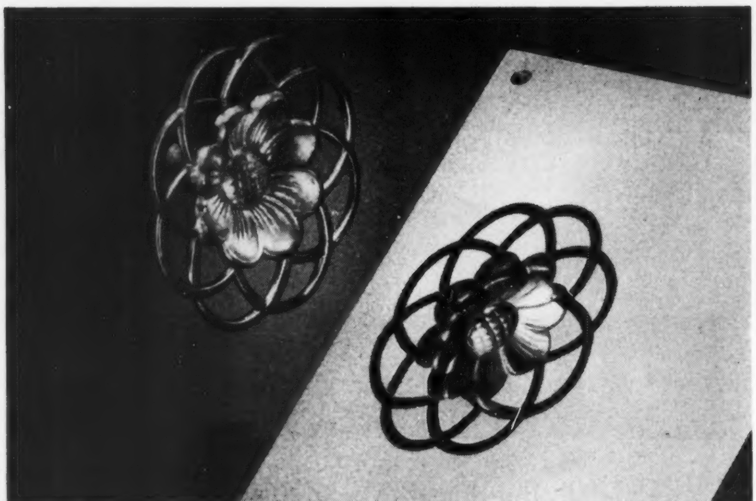


(*Right*)
Holder used in conjunction with a jig for the precise boring of small carbide components.





(*Right*)
An intricate electrode (Mazak) and finished workpiece (high carbon steel).

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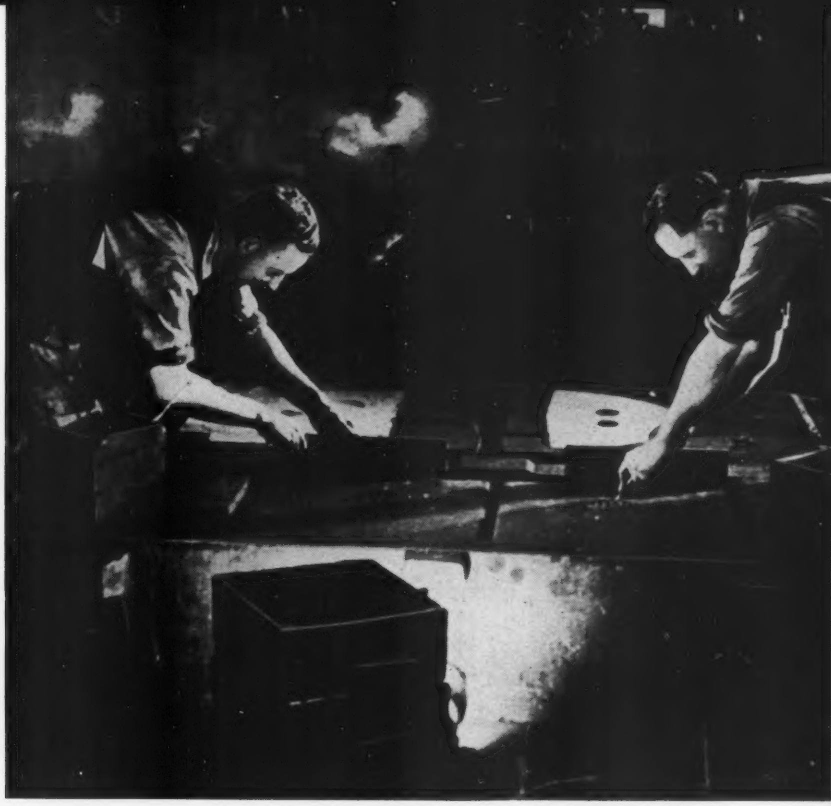

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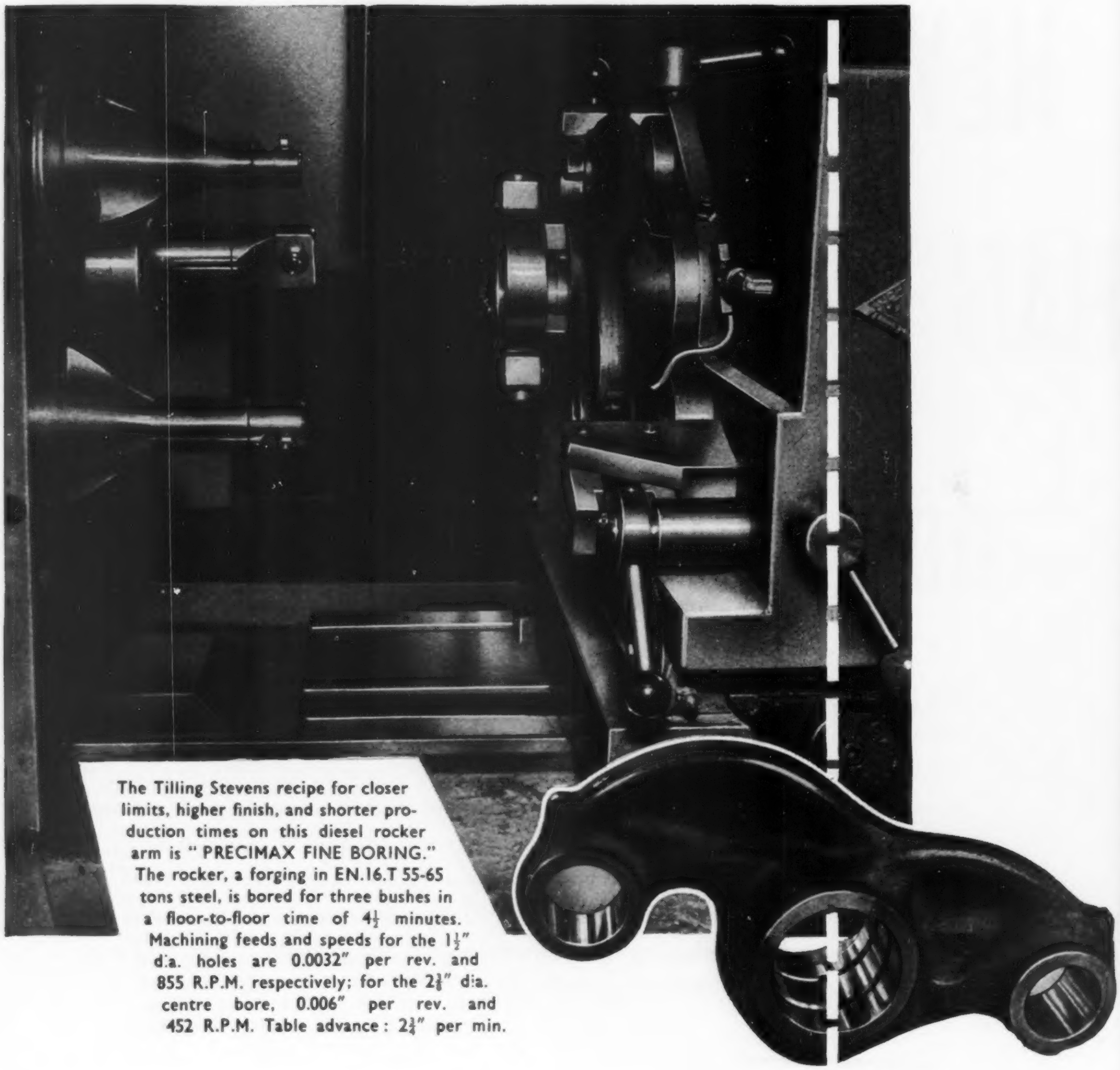
means "PRECIMAX"



The Tilling Stevens recipe for closer limits, higher finish, and shorter production times on this diesel rocker arm is " PRECIMAX FINE BORING." The rocker, a forging in EN.16.T 55-65 tons steel, is bored for three bushes in a floor-to-floor time of 4½ minutes. Machining feeds and speeds for the 1½" dia. holes are 0.0032" per rev. and 855 R.P.M. respectively; for the 2¾" dia. centre bore, 0.006" per rev. and 452 R.P.M. Table advance : 2¼" per min.

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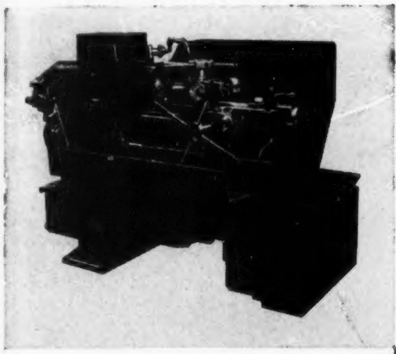

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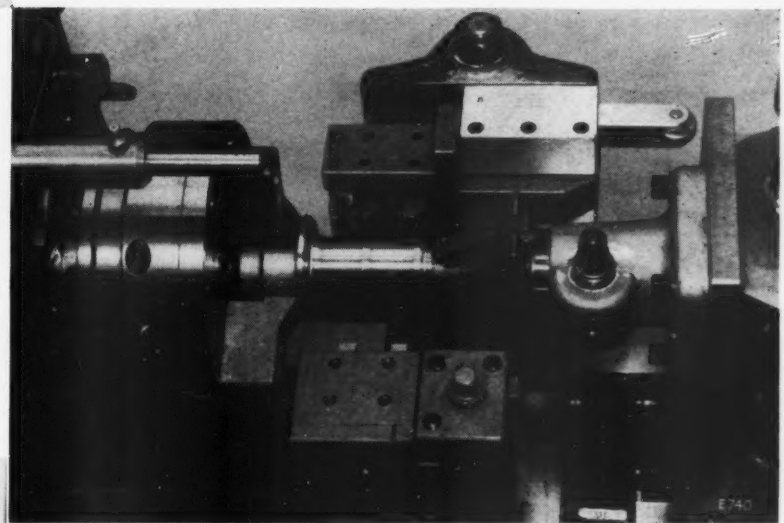
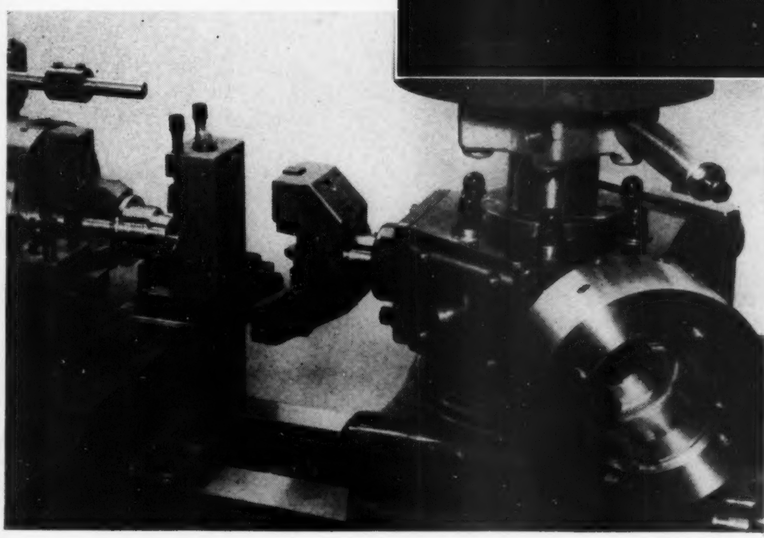


First operation for producing fire hose couplings from brass pressings on a machine fitted with a special cross-slide and profiling slide.

The tools on the profiling slide are fed forward by operation of the cross-slide while the component is supported in the bore by a revolving steady. The turret is then moved forward to actuate the profiling slide and so turn the two 32 mm. diameters simultaneously. Continued movement of the turret radiuses the end and chamfers the bore.

Floor to floor time—12 seconds.



In the second operation on the couplings, the 42 mm. diameter, the taper, the radius on the end and the chamfer in the bore are simultaneously machined with tools held in a standard combined holder on the turret.

Tools held on the cross-slide are then used to radius the flange, undercut and chamfer the thread diameter and undercut the taper. The 42 mm. thread is cut with a $2\frac{1}{4}$ in. Solid Adjustable Diehead mounted on the third turret face.

Floor to floor time—25 seconds.

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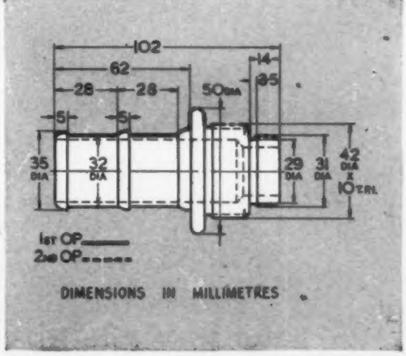

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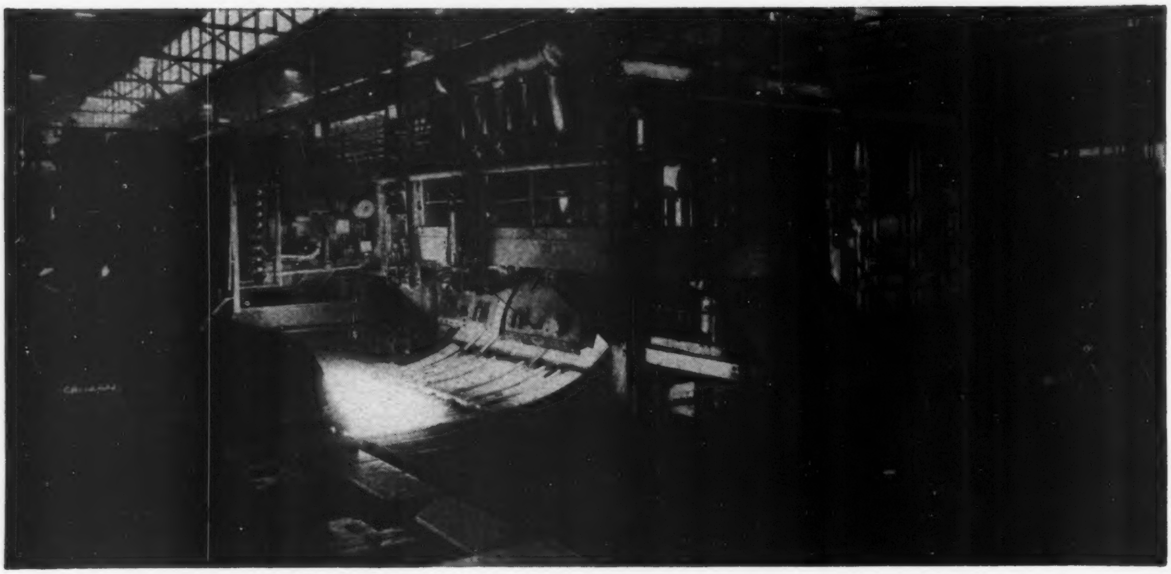

Fig. 1. A hot slab being ejected from the furnace on to the roller table.

THE GLAMOUR OF STAINLESS STEEL

Stainless Steel—a British discovery by Brearley in Sheffield in 1913, overcame the atavistic tendency of ordinary steels to return to iron oxide as rust.

Now highly polished Stainless Steel adds glamour to kitchens and hotel, office and shop fittings. Perhaps more important, its resistance to corrosion offers a hygienic surface to the food manufacturing industries, large scale caterers and for hospital equipment, including sterilisers and the surgeon's delicate instruments.

This glamour applies not only to Stainless Steel products, some of which are illustrated in this article, but also to its processing. In fact, the ultimate durability of Stainless Steel depends upon a precise temperature/time heating and reheating schedule, which processes are usually carried out by town gas because of its inherent flexibility as a heating medium.

Fig. 1 shows a close-up view of a slab heating furnace at Shepcote Lane Rolling Mills Limited—a subsidiary company of Firth-Vickers Stainless Steels Limited, in which Samuel Fox & Co. Limited have a one-third interest. In the illustration a red hot slab has just been ejected on to the run-out table. This furnace heats nine tons of slab hourly at a temperature of 1,230°C before ejection, using 35,000 cubic feet of town gas per hour—each slab weighing approximately three tons.

The impressive machinery used to process Stainless Steel is shown in Fig. 2—the plant producing either matt or mirror-finished coiled strip. In the background are shown the gas-fired slab-heating furnace and the primary rolling section. The gas-fired coil reheating furnaces and the automatically controlled four-high finishing mill together with the run-out table are shown in the foreground.

Fig. 2. A general view of the hot mill bay showing furnaces, Steckel Mill and run-out table.

Fig. 3. The four-high hot Steckel Mill installed at Shepcote Lane Rolling Mills Limited.

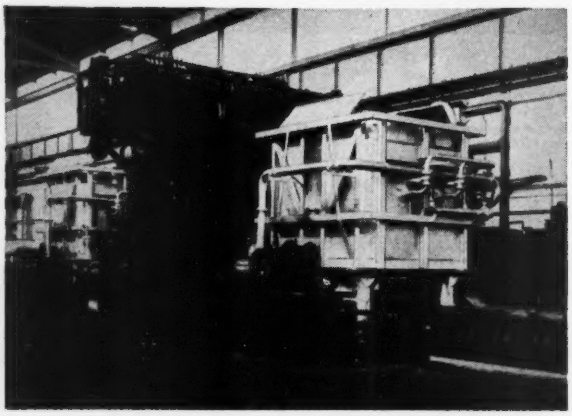

Fig. 3 shows the complex four-high Steckel Mill with its adjacent coil reheating furnaces. Each furnace is rated at 8,000 cubic feet per hour, and the plant will roll up to nine passes with a drop in temperature of the steel of only 250°C.

The treatment of Stainless Steel is only one of thousands of different trades, professions and processes served by the Gas Industry. Each Area Gas Board has specialist staff familiar with the heating problems of these many industries. They all pool their ever-increasing knowledge through the Gas Council's Industrial Gas Development Committee, whilst the Industrial Gas Information Bureau keeps in touch with developments in gas-fired equipment in all parts of the world. Thus any user, or potential user, of gas-fired equipment has a fund of technical knowledge available to him by asking for the services of his Area Gas Board.

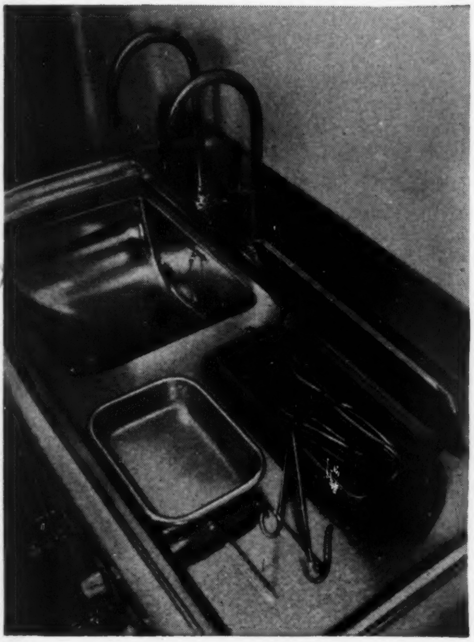

Fig. 4. A sterilising unit for surgical and dental instruments.

Scottish Gas Board, Edinburgh
Northern Gas Board, Newcastle-upon-Tyne
North Western Gas Board, Manchester
North Eastern Gas Board, Leeds
East Midlands Gas Board, Leicester
West Midlands Gas Board, Birmingham
Wales Gas Board, Cardiff
Eastern Gas Board, Watford
North Thames Gas Board, W.8
South Eastern Gas Board, Croydon
Southern Gas Board, Southampton
South Western Gas Board, Bath

The Gas Council 1 Grosvenor Place, London, S.W.1

Fig. 5. Receiving and storage tanks for margarine blends in the processing department of Van Den Berghs & Jurgens Ltd., Stork Margarine Works, Purfleet.

Fig. 6. The Wimpy, Lyon's Corner House, Coventry Street, London.

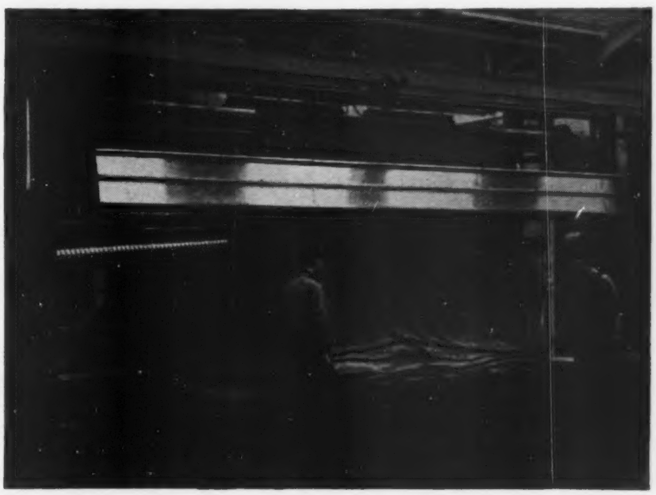

Fig. 7. The largest stainless steel carpet dyeing machine ever produced in Great Britain.

Delapena

Hardening and grinding in one set-up slashes handling costs!

ONE method of harnessing specialised knowledge to produce significant production economies is strikingly illustrated by this use of Delapena Induction Slideway Hardening in conjunction with rough and finish grinding in the production of lathe-beds by T. S. Harrison & Sons Ltd.

Elimination of expensive handling delays has enabled the user to cut costs and achieve increased success in competitive export markets, including the U.S.A.

The advice of Delapena & Son Ltd., acknowledged leaders in the field of Induction Heating equipment, is available to all interested manufacturers. The exclusive Delapena slideway and surface hardening technique, using patented Intensifiers, could help *your* production figures.

The coupon below is an easy means of taking the first steps towards efficiency through Induction Heating.

General view of the installation showing the modified surface grinder with the two Delapena 25 kilowatt induction heaters, one mounted above the other at the rear. The grinding head has been raised clear of the slideway for the hardening process.

The induction hardening head, showing the twin Intensifiers, fed one from each heater, traversing the two slideway surfaces.

Photographs and information by kind permission of T. S. Harrison & Sons Ltd.

Please send me further information about induction heating particularly as applied to: ....

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POSITION ....

FIRM ....

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Specialist Engineers in Induction Heating

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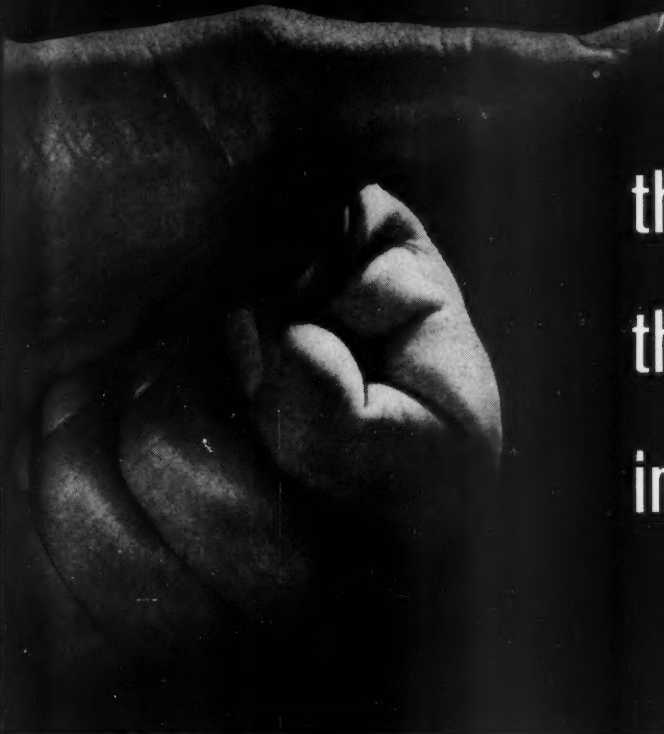
This is the thumb that starts the machine that cuts gears faster than any other machine in the world



Whose thumb is it? It could be anyone's. The ownership of the thumb is unimportant. It's the ownership of the machine that counts. For the machine is a Hydrax — the world's most advanced gear hobber. Anyone who owns a Hydrax cuts gears at an astonishing speed — automatically — accurately. Hydrax hobbing means multi-spindle production from a single-spindle machine. If you really want to get hobbing, you'll want information about the Hydrax range. We'll be glad to send you literature.

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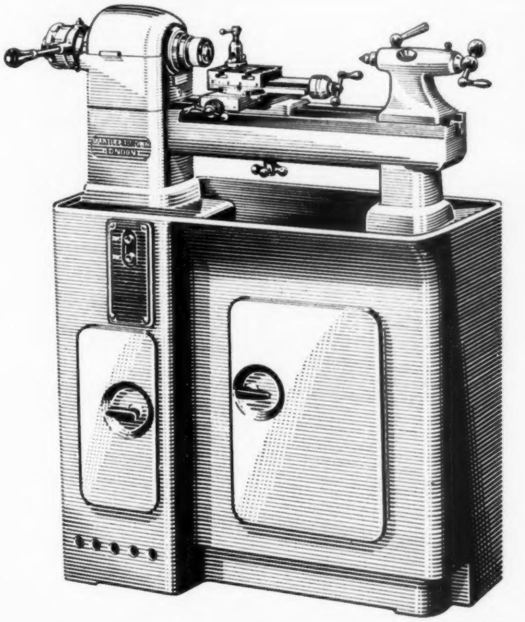

Sixteen Standard Models Available

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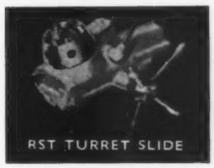
Numerous combinations can be obtained with standard attachments. Direct motor and countershaft drives can be furnished.
EPICYCLIC GEARBOX is now available giving a wide range of spindle speeds.



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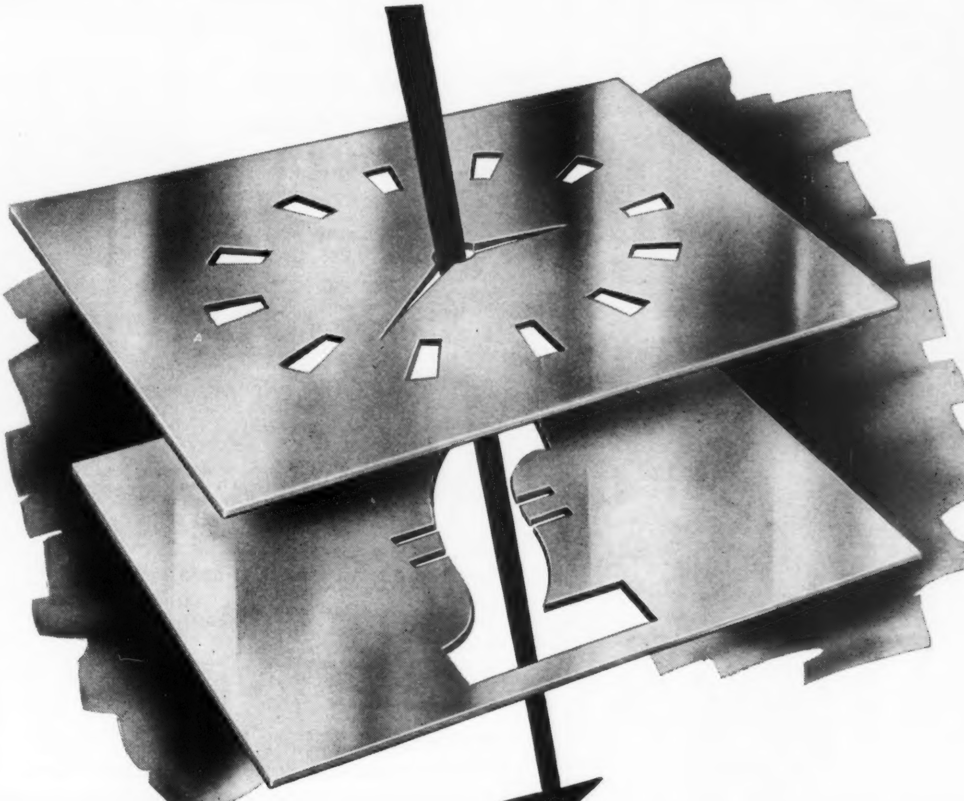

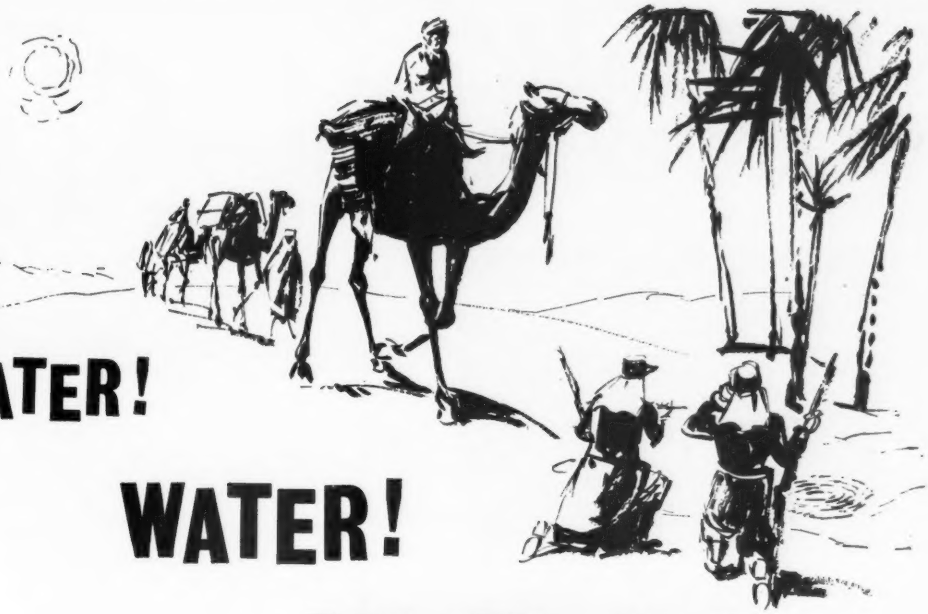

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1959 saw one of the greatest shortages of water that this country has ever experienced. It could happen in 1960—or any other year.

Do not risk your output being hampered or your business shut down, through reduction of town-water pressure, or actual cutting-off of supplies.

The Heenan Water Cooler uses the same cooling water over and over again. Be independent of the town's water supply—INSTALL NOW. Apart from all these advantages

THE HEENAN COOLER QUICKLY PAYS FOR ITSELF

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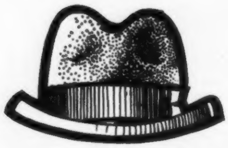

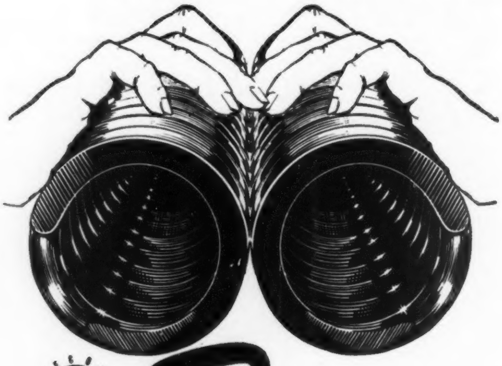

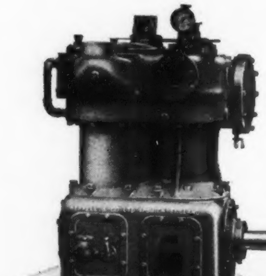

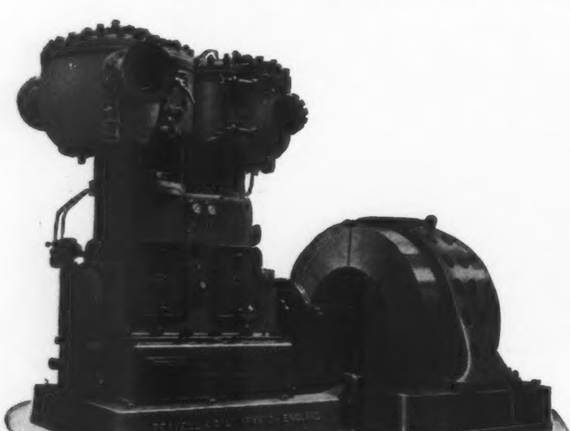

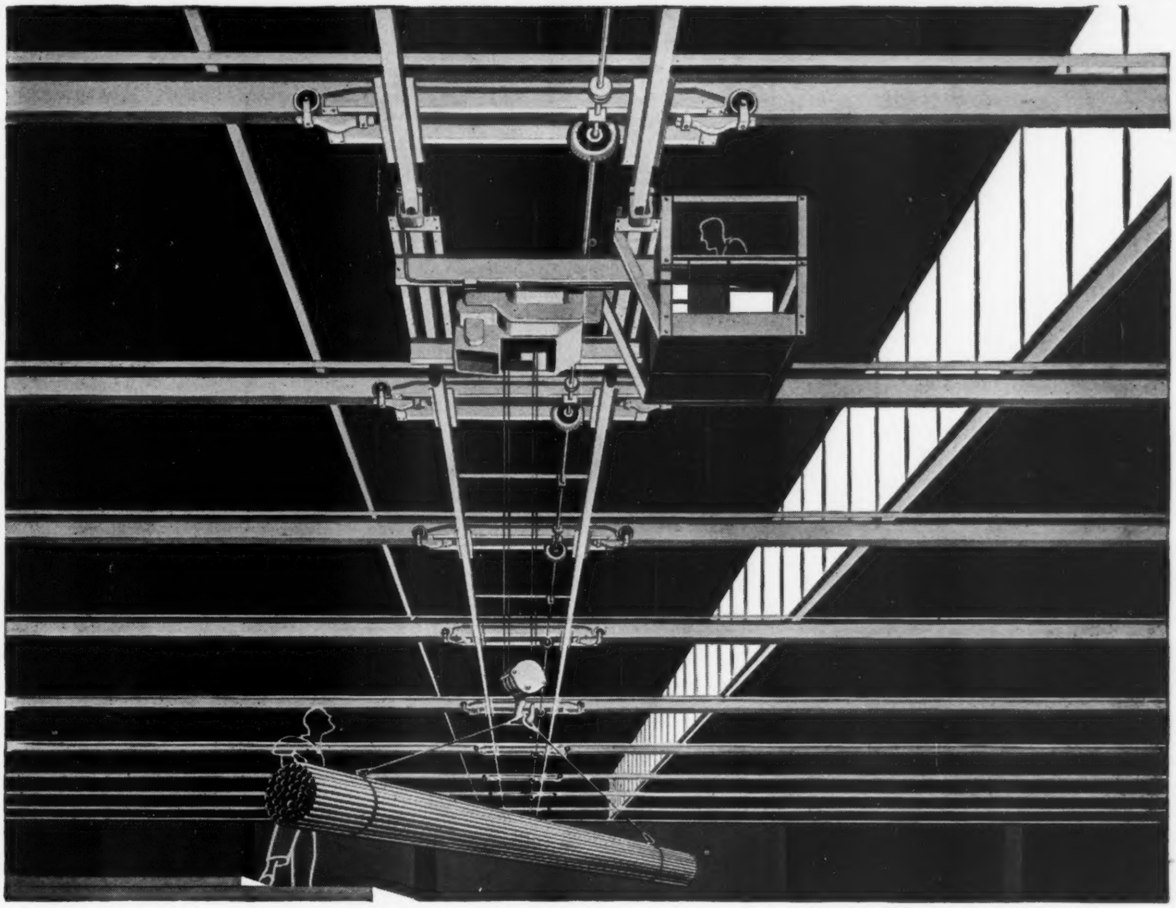

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